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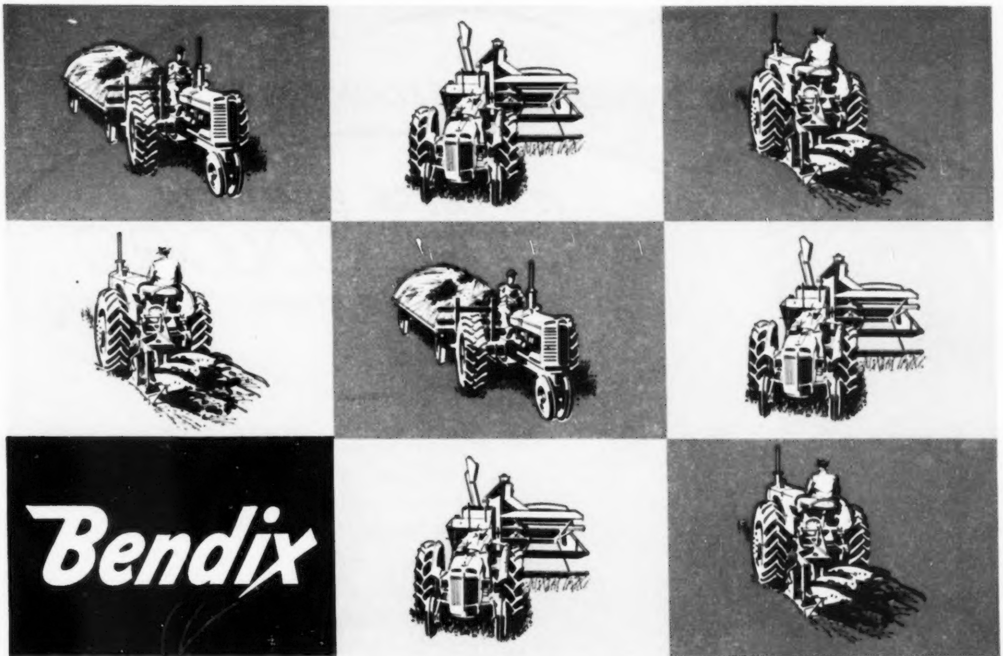
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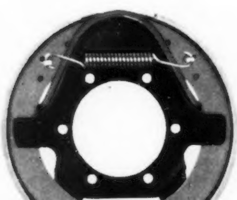

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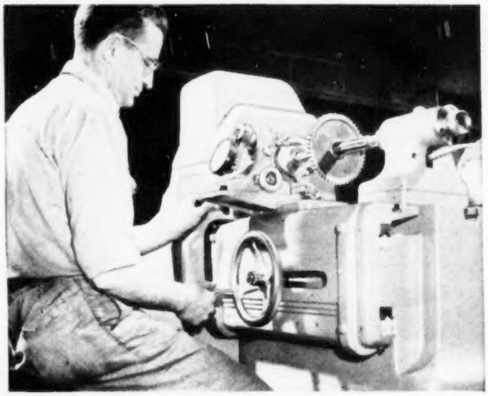
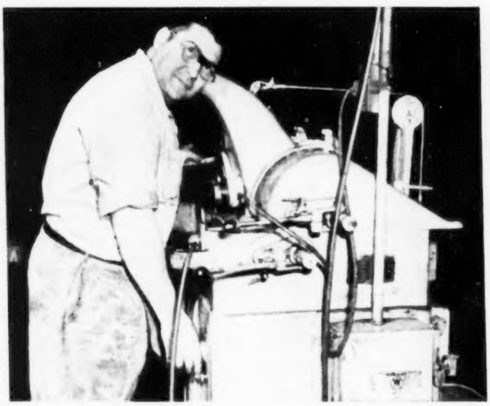
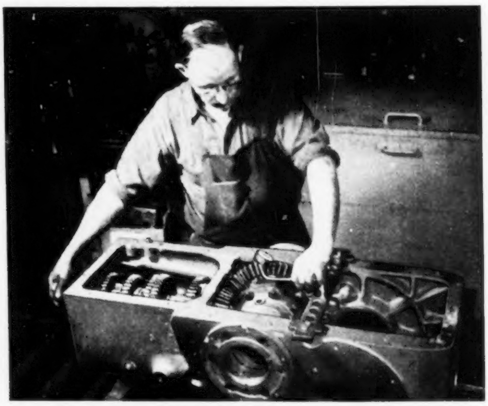


Heading off gear "toothaches" is the job of this IH expert. He is using a gear tester to make sure spur gear teeth are parallel with the gear bore. If any of the teeth on meshing gears are crooked, the whole power load is pin-pointed on a tiny area. This can cause tooth breakage. The dial indicator on this tester, which is sensitive to the ten-thousandth of an inch, points out even slightly misshapen teeth.



Gears cry, if they have troubles, to this IH technician. When he runs a gear on his tester, the sound tells him whether gear tooth form, finish, and concentricity measure up to IH standards. Poor finish, for instance, will make the gear "talk" at idle speeds. Imperfect tooth form causes noise when brake pressure is applied to simulate actual power loads on the gear. Every constant-mesh tractor gear must pass this sound test.



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EDITORIAL

CEC Opportunities

AS THE date approaches for the Centennial of Engineering Convocation, September 3 to 15, it seems appropriate to again remind agricultural engineers of the double opportunity of the occasion. The main feature from their standpoint will be the program presented by the American Society of Agricultural Engineers, September 8 and 9.

This program is an opportunity to develop an improved understanding and appreciation of agricultural engineering among others — representatives of other branches of engineering; agricultural, industrial, and educational leaders; and young men looking forward to useful careers.

The other opportunity provided is for agricultural engineers to take a new look backward and forward. It is a look to be taken carefully, as preparation for further individual and professional progress which will not lag behind that of other branches of engineering.

Sound Promotion of Farm Processing

TO SOME few agricultural engineers with a particular interest in the processing of farm products, progress and interest in that line may seem to lag unaccountably.

It must be remembered that farm processing is far older than the urban industrialized processing of farm products. Urban industry learned to improve on farm processing in economy, sanitation, uniformity of product, by-product utilization, and merchandising. It developed its advantages in industrial organization; capital, labor and materials supply; large-scale operation and other factors. It overcame some of its natural disadvantages in distance from its sources of supply, depreciation of perishables, and transportation of bulk and waste. It developed and utilized technological help.

This net advantage of urban over rural processing, however, is not necessarily permanent, overwhelming, or insurmountable. The balance is influenced by a wide variety of economic and social changes and technological progress. Farms and farming communities may again have advantages over cities as locations for additional farm product processing operations.

Rural electrification has given farmers a new tool of special value in process operation and control. Rural communities have gained on metropolitan areas tremendously as an all-around satisfactory environment for efficient living with maximum opportunity for effective work and recreation. Rising transportation, tax and other costs discourage the large tonnage and large-volume shipment of waste water and low-value fiber from farms to distant processing points.

With a few possible exceptions, however, opportunities for specific rural-processing operations to prove successful under current conditions have not been carefully analyzed and clarified. Combinations of technical process, equipment, and operating method problems beyond the common knowledge of leaders in small-scale business are evident factors properly suggesting extreme caution against unstudied financial plunges into rural processing.

Some agricultural engineers have found support for service work on behalf of established operations in farm and rural processing, and for preliminary general studies of the field. They have classified and listed the types of activities, the unit operations and the related technologies involved. In the ASAE Committee on Agricultural Processing they have developed some cohesion and continuity of interest in processing as a field to which agricultural engineering principles, equipment, and practices could prove extremely helpful. The committee invites suggestions as to how it might further contribute to the sound development of farm processing.

If support can be found for their further study of specific processing activities, and evaluation of the factors contributing to success in such operations, they might bring to light some surprising undeveloped opportunities for the profitable further processing of farm products on individual farms or in farming communities.

They might also save farmers and others considerable loss in experiments with such processing where one or more of the conditions necessary to success may be lacking.

The lag in farm processing is not due to a lack of incentive. It is not due to a lack of men with the spirit of free enterprise. It is not due to a lack of men with the required technical ability. It seems likely that it is due to a lack of well-defined starting points for the initiation of specific new enterprises or equipping farms for additional operations. If agricultural engineers can clarify some of those starting points, they will be rendering a major engineering service to agriculture.

Notes on Job Hunting

A RECENT study of job opportunities by a graduating senior in agricultural engineering provides substantial food for thought on the part of others seeking employment, and employers as well.

In considering opportunities with 13 different industrial employers this man made 6 special trips totaling over 5,000 miles. His wife accompanied him on nearly half of this travel, as a principal directly influencing a man's potential values to the company and his continuing interest in one job or another. He spent 172 hours on traveling and waiting, 104 hours being interviewed, and had further contacts with those 13 employers through 91 letters, 11 telephone calls, and 2 telegrams. He figures that, altogether, the total direct cost of his placement was over $1,600, including over $600 in direct travel costs paid by the interested employers.

Factors apparently within the control of management, which this man found unfavorable in some cases, included failure to invite him to visit the plant, lack of provisions for further training, low starting salary and advancement opportunities limited by seniority or type of work.

Other factors beyond the control of management largely involved the personal preferences and interests of the individual.

Starting salaries offered ranged from $280 to $350 per month, and averaged $326. These were offers to a graduate of an accredited 4-year curriculum with a bachelor's degree in agricultural engineering, somewhat above average in maturity, and with high scholastic, activity, and personality ratings.

This man credits the college engineering personnel office and the interviewers contacted with a strong assist in his effort to secure the type of work he wanted. He did, however, exert considerable effort in that direction on his own initiative. The company to which he finally sold his services sent interviewers to the college to interview seniors in other branches of engineering and science. He asked for and received a special interview. In his subsequent visit to the company he was further interviewed by three separate departments. In one of them which had never before employed an agricultural engineer, he found that he and the department head shared a strong common interest and outlook on development of the class of products concerned and their future in agricultural applications. That is where he accepted employment.

In conclusion, this graduate says "There are two major reasons why I selected the job I did. One is the splendid advancement opportunity which I felt existed, and the other is that the job is the type of work which I think I like best. In the final analysis I found that I gave secondary importance to other factors such as salary, job security, geographic location, kind of city, amount of traveling, and how closely the job conformed to my college major."

Current active demand for engineering graduates does not mean that the individual graduate will easily and automatically find the work for which he may be best suited. It does mean that employers are providing more and better opportunities than ever before, for the individual graduate to use his initiative in finding and making a place for himself in engineering work awaiting qualified men.

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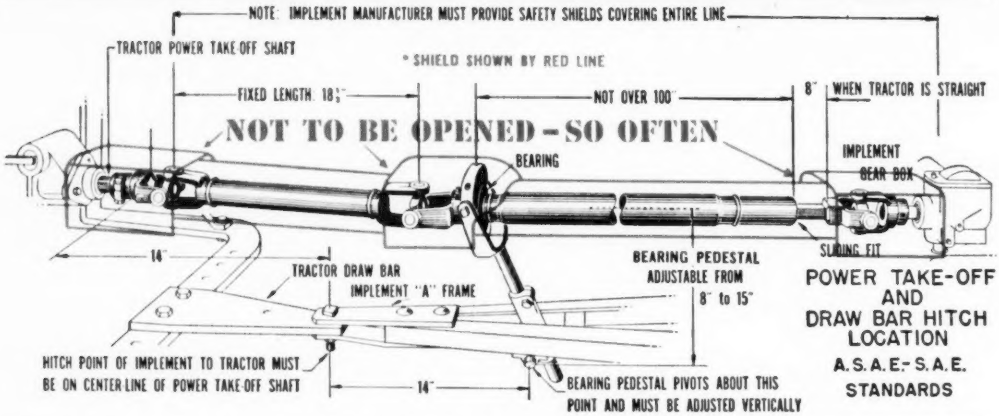

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AGRICULTURAL ENGINEERING

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Three-Member Joints for Nailed Trussed Rafters

By Paul W. Stoneburner

Assoc. Member ASAE

SUMMARY

Tests were conducted on three-member southern pine joints to *(a)* determine the relationship of the lateral load-carrying capacity of nails in single and double shear, and *(b)* to develop a basis for structural design data for laterally loaded nails in double shear applicable whenever deformation is a governing factor, such as in joints of trussed rafters.

The test loads at or near proportional limit show that low-carbon-steel, plain-shank and helically threaded Screwtite nails loaded in double shear carry twice the single-shear loads, while hardened high-carbon-steel, plain-shank and Screwtite nails loaded in double shear carry considerably less than twice the single-shear loads. If these relationships between single-shear and double-shear loads are to be valid, the nail must be of optimum diameter for the joint.

Structural design data as based on test loads at or near proportional limit for laterally loaded low-carbon-steel, plain-shank nails in single and double shear are applicable to low-carbon-steel helically threaded Screwtite nails and to same-length, smaller-diameter, hardened high-carbon-steel, plain-shank and Screwtite nails. This finding, however, is not valid if consideration is to be given to the load-carrying capacity beyond proportional limit and at ultimate, to the influence of exposure on nail-holding power, and to certain advantages resulting from the use of threaded-shank as well as hardened nails.

Design data as advanced in the National Design Specification for low-carbon-steel, plain-shank nails in single shear are verified within their scope.

INTRODUCTION

Wood trussed rafters with nailed joints may have either or both two-member or three-member joints in which the nails are loaded in shear and bending. This type of loading is called lateral loading. If one nail fastens two members, the nail is laterally loaded in single shear as only one shear surface is created. If one nail fastens three members, the nail is laterally loaded in double shear as two shear surfaces are created. Because of the ease of assembly, the need for fewer nails, and the possibility of greater lateral load-carrying capacity, it may be desirable to use nails in double shear rather than in single shear whenever possible.

Structural design data for nails in lateral loading are few in the United States. The "National Design Specification for Stress-Grade Lumber and Its Fastenings" (1)* is the current design manual generally used by engineers engaged in the design of wood structures. Allowable loads for nails in lateral loading are given for common wire nails in single shear. Adjustments are permitted for unseasoned wood, metal side plates, end grain, and duration of loading. These data are not sufficient to allow adequate designs for nails in many types and conditions of lateral loading.

One of the best examples of nailed three-member joints is the heel joint of a trussed rafter where the rafter is joined to the lower chord by two splice plates, one on each side. If this three-member joint is fastened with nails long enough to penetrate all three members at once, the joint can be made more easily and with less nails than if each splice plate is fastened to the center member with short nails that do not penetrate the opposite splice plate. However, American design data are applicable only to nails in single shear where two members are joined and one shear surface is created. Thus the structural designer can use nails in single shear only, or else rely on his own judgment for determining the lateral load-carrying capacity of nails in double shear.

German design specifications for nailed joints (2) state that a nail in double shear is assumed to transmit twice as much load as a nail in single shear. K. Schmid of Switzerland (3) has presented formulas which allow the computation of the load-carrying capacity of nails in three-member joints of varying lumber thicknesses. However, all three joint members must be of equal thickness to allow application of these data. Thus design data for lateral loading of nails in double shear are limited even in European countries where nailed structures are more predominant than in the United States, and where specifications for nailed construction provide detailed design information.

TESTS TO ESTABLISH GENERAL TREND

Fig. 1 presents the test procedures employed and shows the relationship of the lateral load-carrying capacity of nails in single and double shear according to matched tests. Single compression tests were performed on joints assembled with $2\frac{1}{2}$, 3, $3\frac{1}{4}$, $3\frac{1}{2}$, and 4-in-long plain-shank and helically threaded Screwtite† nails (4) made of low-carbon and hardened high-carbon steels. A total of 17 three-member joints was assembled with graded and inspected clear, dense-select-structural, green southern pine. An electronically recording Olsen Universal testing machine with a 6000-lb capacity poise was used with a spherical seat fastened to the crosshead of the machine to assure concentric load application.

Since the cross section of the three-member joints was symmetrical, compression tests were suitable and preferred to tension tests, particularly as similar test results can be expected. Possible end-splitting of the test members may be prevented in compression joints. On the other hand, such restraint is of no influence on the test data, because the selected amount of end distance is adequate to prevent end-splitting even under tension loading.

The U.S. Forest Products Laboratory equation for lateral load-carrying capacity of nails in single shear is based on proportional-limit loads (5). Since it is often difficult to determine the proportional limit of the tested nailed joints with the required degree of accuracy, it is desirable to have a more accurate basis for this equation than is provided by proportional-limit load. Such a basis is available, since "in general, it can be assumed that proportional limit for a nailed joint is reached at a slip of about 0.015 in" (6).

Using the load carried by one $2\frac{1}{2}$-in long nail at 0.015-in joint deformation as the load P in the Forest Products Labora-

This paper, prepared expressly for Agricultural Engineering, is a condensation of a thesis by the author in partial fulfillment of the requirements for the degree of master of science in agricultural engineering. The investigation was conducted in the wood research laboratory of the Virginia Polytechnic Institute as a cooperative project of the VPI agricultural and engineering experiment stations, with the Independent Nail and Packing Co., Bridgewater, Mass., as cosponsor.

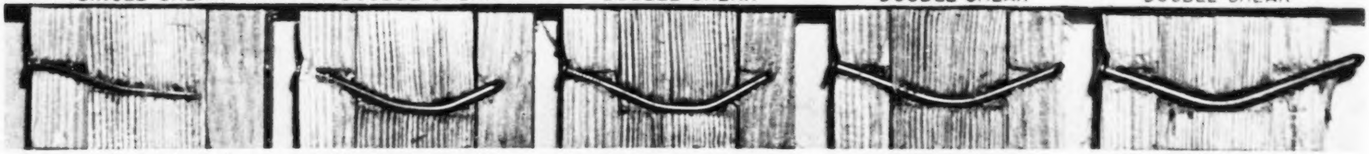
The author: Paul W. Stoneburner, formerly assistant agricultural engineer, Virginia Polytechnic Institute.

Author's Note: Acknowledgement is made of the invaluable contributions to this study by Dr. E. George Stern, research professor of wood construction, who supervised the prosecution of the project, and to Robert C. Hodge, laboratory mechanic, who assisted in the construction of the test joints and the performance of the tests.

*Numbers in parentheses refer to the appended references.

†A product of the Independent Nail & Packing Co., Bridgewater, Mass.

SINGLE SHEAR — DOUBLE SHEAR — DOUBLE SHEAR — DOUBLE SHEAR — DOUBLE SHEAR



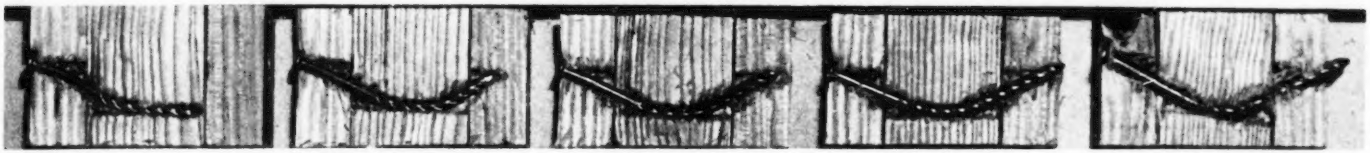
2½ x 0.135-in L-C plain-shank nail
0.015-in joint deformation — 175 lb
Proportional limit — 250 lb
Ultimate — 520 lb

3 x 0.148-in L-C plain-shank nail
0.015-in joint deformation — 250 lb
Proportional limit — 200 lb
Ultimate — 675 lb

3¼ x 0.148-in L-C plain-shank nail
0.015-in joint deformation — 175 lb
Proportional limit — 150 lb
Ultimate — 735 lb

3½ x 0.162-in L-C plain-shank nail
0.015-in joint deformation — 215 lb
Proportional limit — 180 lb
Ultimate — 715 lb

4 x 0.203-in L-C plain-shank nail
0.015-in joint deformation — 250 lb
Proportional limit — 250 lb
Ultimate — 1150 lb



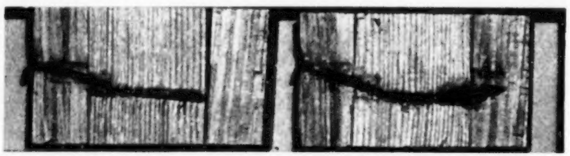
2½ x 0.135-in L-C Screwtite nail
0.015-in joint deformation — 160 lb
Proportional limit — 160 lb
Ultimate — 1020 lb

3 x 0.148-in L-C Srewtite nail
0.015-in joint deformation — 180 lb
Proportional limit — [illegible]
Ultimate — 780 lb

3¼ x 0.148-in L-C Screwtite nail
0.015-in joint deformation — 200 lb
Proportional limit — 245 lb
Ultimate — 1090 lb

3½ x 0.162-in L-C Screwtite nail
0.015-in joint deformation — 200 lb
Proportional limit — 250 lb
Ultimate — 1260 lb

4 x 0.203-in L-C Screwtite nail
0.015-in joint deformation — 275 lb
Proportional limit — 400 lb
Ultimate — 1750 lb

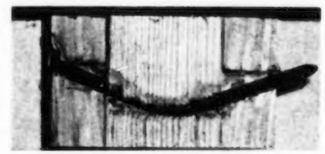


2½ x 0.120-in H H-C plain-shank nail
0.015-in joint deformation — 220 lb
Proportional limit — 200 lb
Ultimate — 935 lb

3 x 0.135-in H H-C plain-shank nail
0.015-in joint deformation — 235 lb
Proportional limit — 200 lb
Ultimate — 925 lb

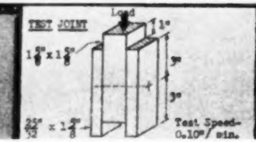
Joints with	Average moisture content	Average specific gravity
Low-carbon-steel plain-shank nails	22 per cent	0.63
Low-carbon-steel Screwtite nails	22 per cent	0.58
Hardened high-carbon-steel plain-shank nails	20 per cent	0.60
Hardened high-carbon-steel Screwtite nails	18 per cent	0.57

NOTE: All joints for nails of the same type are end-matched, thus providing fully comparable test results.

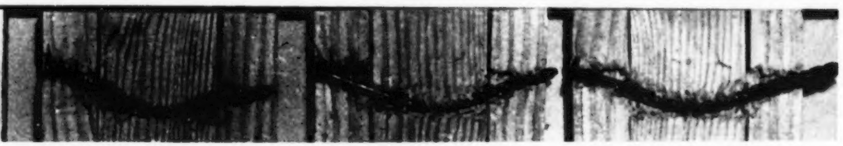


4 x 0.177-in H H-C plain shank nail
0.015-in joint deformation — 325 lb
Proportional limit — 250 lb
Ultimate — 1450 lb

2½ x 0.120-in H H-C Screwtite nail
0.015-in joint deformation — 190 lb
Proportional limit — 170 lb
Ultimate — 980 lb



NOTE: For tests on nails 2½ in long, two nails were used instead of one. The nails were driven one from each side and spaced ⅜ in apart perpendicular to the grain of the lumber.



3¼ x 0.135-in H H-C Screwtite nail
0.015-in joint deformation — 180 lb
Proportional limit — 215 lb
Ultimate — 920 lb

3½ x 0.148-in H H-C Screwtite nail
0.015-in joint deformation — 210 lb
Proportional limit — 200 lb
Ultimate — 1170 lb

4 x 0.177-in H H-C Screwtite nail
0.015-in joint deformation — 215 lb
Proportional limit — 380 lb
Ultimate — 1690 lb

Fig. 1 Single shear versus double shear for nails in three-member southern pine compression joints tested immediately after assembly

TABLE 1. Average Immediate Lateral Load-Carrying Capacity of Nails in Three-Member, Green Southern Pine Compression Joints

Nails in Joint	Nail Size Length -In.-	Nail Size Diam -In.-	Nail Type	Test Plank	Load in Pounds at Prop Limit	0.015" Def	0.030" Def	Ultimate
2	2½	0.120	HHC PS	A	---	256	336	896[1]
2	2½	0.120	HHC Sc	A	229	289	363	1185[1]
2	2½	0.135	LC PS	B	---	201	257	418[1]
2	2½	0.135	LC Sc	B	---	180	257	810[1]
1	3	0.135	HHC PS	A	---	208	271	805[1]
1	3	0.135	HHC Sc	A	---	192	277	502[4]*
1	3	0.148	LC PS	A	---	196	251	513[1]
1	3	0.148	LC Sc	A	239	285	347	775[1]
1	3½	0.148	HHC Sc	A	---	231	302	1008[2]
1	3½	0.162	LC PS	A	253[4]	282[4]	355[4]	660[1]
1	3½	0.162	LC Sc	A	---	251[4]	336[4]	981[1]
1	4	0.177	HHC PS	A	---	322	419	1284[2]
1	4	0.177	HHC Sc	A	---	287	401	1048[2]*
1	4	0.203	LC PS	B	228[4]	272[4]	356[4]	882[1]
1	4	0.203	LC Sc	B	---	250	398	1184[1]

HHC — hardening high-carbon steel
LC — low-carbon steel
PS — plain-shank
Sc — Screwtite
Test Plank A — 23 per cent, 0.55
Test Plank B — 26 per cent, 0.50
*Nail broke

Average test results based on five tests except as noted by respective index numbers.

tory equation, $P = KD^{3/2}$, K can be determined for each nail type on the basis of the test results. Applying this computed K, the load which would be carried by the 3, 3¼, 3½, and 4-in-long nails in single shear can be computed. Thus a basis of comparison can be provided for computed lateral load-carrying capacities of those nails in single shear versus those in double shear as obtained from test results.

The joints shown in Fig. 1 were split open after testing to ultimate load; hence, the condition of nail and surrounding wood similar to that at ultimate load can be observed.

Average double-shear loads for the low-carbon-steel, plain-shank and helically threaded Screwtite nails are 190 and 198 per cent, respectively, or twice the computed single-shear loads. Average double-shear loads for the hardened high-carbon-steel, plain-shank and threaded-shank nails are 172 and 149 per cent, respectively, of the computed single-shear loads.

TABLE 2. Average Immediate Lateral Load-Carrying Capacity of Nails at 0.015-in Total Deformation of Three-Member Southern Pine Compression Joints of 23 per cent Average Moisture Content and 0.55 Average Specific Gravity

Nail Size Length -In.-	Diameter -In.- High-Carbon	Diameter -In.- Low-Carbon	Low-Carbon Steel Plain-Shank Load in Lbs	Low-Carbon Steel Screwtite Load in Lbs	Hard High-Carbon Steel Plain-Shank Load in Lbs	Hard High-Carbon Steel Screwtite Load in Lbs
2½**	0.120	0.135	201*(100%) (100%)	180*(90%) (90%)	256 (100%) (127%)	289 (113%) (144%)
3	0.135	0.148	196 (100%) (100%)	285 (145%) (145%)	208 (100%) (106%)	192 (92%) (98%)
3½	0.148	0.162	282 (100%) (100%)	251 (89%) (89%)	--- ---- ----	231 ---- (82%)
4	0.177	0.203	272*(100%) (100%)	250*(91%) (91%)	322 (100%) (118%)	287 (89%) (106%)
	Average		100% 100%	104% 104%	100% 117%	98% 108%

*Test specimens of 26 per cent average moisture content and 0.50 average specific gravity

**In joints with 2½-in long nails, two nails were used instead of one.

It can be noted that for every nail type, double-shear loads for the 4-in-long nails are not proportionally as high as the respective loads for the 3, 3¼, and 3½-in-long nails. This finding substantiates previous tests which have established the factor of optimum nail diameter (3). Thus, if the diameter of the nail is too large for the thickness of the joint, loads will not be as large as would be possible for a thicker joint assembled with the given nail. Hence, excluding the 4-in-long nail in the single-shear versus double-shear comparisons, average double-shear loads are 203 and 201 per cent, respectively, of single-shear loads for low-carbon-steel, plain-shank and threaded-shank nails, and 179 and 160 per cent, respectively, of single-shear loads for hardened high-carbon-steel, plain-shank and threaded-shank nails.

Restricted by the limitations of the test data, the following conclusions can be noted:

1 Low-carbon-steel, plain-shank and threaded-shank nails loaded in double shear carry twice single-shear loads, while hardened high-carbon-steel, plain-shank and threaded-shank nails loaded in double shear carry only 1¾ and 1½ times, respectively, the single-shear loads.

2 The optimum nail diameter for the low-carbon-steel, plain-shank and threaded-shank nails in the tested three-member joints is near 0.162 in, while for the hardened high-carbon-steel, plain-shank and threaded-shank nails it is near 0.148 in.

Fig. 2 (Left) From left to right, low-carbon-steel plain-shank and helically threaded Screwtite nails of 0.135-in diameter by 2½-in length, 0.148-in by 3-in, 0.162-in by 3½-in, and 0.203-in by 4-in • Fig. 3 (Right) From left to right, hardened high-carbon-steel, plain-shank and helically threaded Screwtite nails of 0.120-in diameter by 2½-in length, 0.135-in by 3-in, 0.148-in by 3½-in, and 0.177-in by 4-in

TESTS TO DEVELOP DESIGN DATA

Additional quintuple tests were performed on similar joints to develop design data for nails in double shear. In contrast to the previous procedure, the length of the test specimens varied for each nail diameter in accordance with German design specifications (2), which require a minimum loaded end distance of 15 nail diameters.

The nails used for joint assembly are shown in Figs. 2 and 3. The joints, end-matched to allow direct comparison of test results, were of southern pine having a specific gravity of 0.50 - 0.55 and a moisture content of 23 - 26 per cent. Individual load-deformation curves are shown in Fig. 4 and average test results are presented in Table 1.

Single Shear versus Double Shear. Average double-shear loads at 0.015-in joint deformation for the low-carbon-steel, plain-shank and threaded-shank nails are 178 and 214 per cent, respectively, of the computed single-shear loads, with the grand average double-shear load being 196 per cent, or twice the single-shear load. Excluding the 4-in-long nails in the comparison, the grand average double-shear load is 218 per cent of the single-shear load. Average double-shear loads at 0.015-in joint deformation for the hardened high-carbon-steel, plain-shank and threaded-shank nails are 138 and 115 per cent, respectively, of the computed single-shear loads.

Where possible, proportional-limit loads were obtained from the load-deformation curves. These proportional-limit loads are 16 and 67 per cent, respectively, smaller than the average loads at 0.015 and 0.030 in joint deformations.

Influence of Nail Type. (a) Plain-Shank versus Helically Threaded Low-Carbon-Steel Nails. As indicated in Table 2, average loads at 0.015-in total joint deformation for helically threaded Screwtite nails vary for the four nail sizes tested from 11 per cent smaller to 45 per cent larger than those for the plain-shank nails, with the grand average load being 4 per cent larger for the threaded-shank than for the plain-shank nails. At twice this joint deformation, that is, at 0.030 in, the grand average loads are 12 per cent larger for the threaded-shank than for the plain-shank nails. Grand average ultimate loads are 45 per cent larger for the threaded-shank than for the plain-shank nails. Thus helically threaded Screwtite nails carry larger loads especially at relatively large joint deformations than plain-shank nails.

(b) *Plain-Shank versus Helically Threaded Hardened High-Carbon-Steel Nails.* As indicated in Table 2, average loads for the threaded-shank nails at 0.015-in joint deformation are from 11 per cent smaller to 13 per cent larger than those for plain-shank nails, with the grand average load being

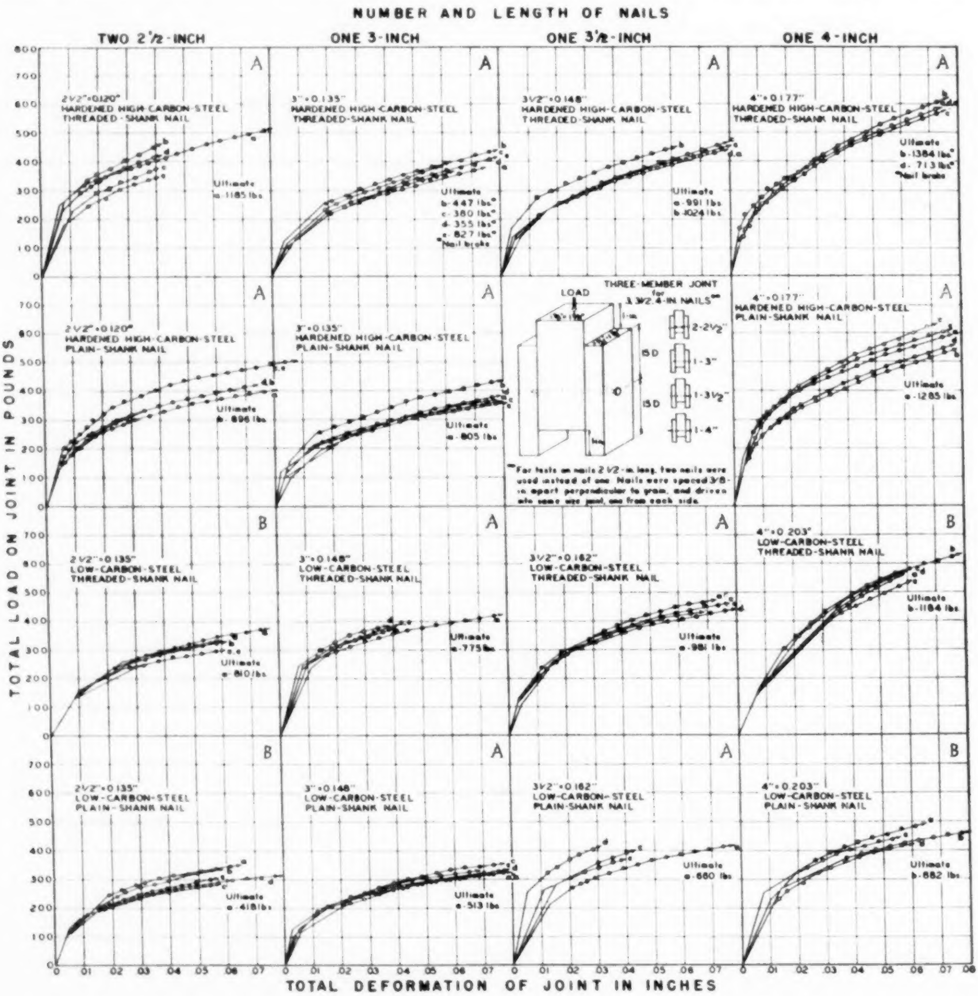


Fig. 3 Lateral load-carrying capacity of nails immediately after driving into three-member southern pine joint loaded parallel to the grain (Threaded-shank nail: Screwtite nail. Southern pine (short leaf), 19 to 26 per cent moisture content and 0.52 average specific gravity. Test speed: 0.048 in per min. A: test plank "A", B: test plank "B")

2 per cent smaller for the threaded-shank than for the plain-shank nails. At 0.030-in joint deformation, the grand average load is 2 per cent larger for the threaded-shank than for the plain-shank nails. Thus the hardened high-carbon-steel plain-shank and threaded-shank nails carry approximately the same loads.

(c) *Hardened High-Carbon-Steel versus Non-Hardened Low-Carbon-Steel Nails.* As indicated in Table 2, at a joint deformation of 0.015 in, the hardened high-carbon-steel, plain-shank nails carry 17 per cent larger average loads than the low-carbon-steel, plain-shank nails, although the former nails are of smaller shank diameters. Grand average loads for the low and high-carbon-steel Screwtite nails are approximately equal at this joint deformation.

At ultimate loads, the 3½-in-long low-carbon and hardened high-carbon-steel, threaded-shank nails carry approximately the same loads, which are 49 and 50 per cent, respectively, larger than those loads for the corresponding low-carbon-steel, plain-shank nails. The hardened high-carbon-steel, plain-shank 3 and 4-in-long nails carry 50 per cent larger average ultimate loads than the corresponding low-carbon-steel nails. Thus hardened high-carbon-steel, plain-shank and threaded-shank nails with smaller shank diameters than same-length, low-carbon-steel nails are as effective at ultimate loads as threaded-shank, low-carbon-steel nails.

Within the limitations of the test data, it may be concluded:

1 Low-carbon-steel, plain-shank and threaded-shank nails loaded in double shear carry twice the single-shear loads. On the other hand, hardened high-carbon-steel, plain-shank and threaded-shank nails loaded in double shear carry one-third more and very little more, respectively, than the corresponding single-shear loads.

2 Low-carbon-steel, threaded-shank nails carry one-seventh and one-half more, respectively, at 0.030-in joint deformation and at ultimate loads than plain-shank nails, although approximately the same loads at 0.015-in joint deformation.

3 Hardened high-carbon-steel, plain-shank and threaded-shank nails carry approximately the same loads at 0.015-in and 0.030-in joint deformations.

4 Hardened high-carbon-steel, plain-shank nails carry, at 0.015-in and 0.030-in joint deformations, one-fifth greater loads than the corresponding low-carbon-steel nails, and hardened high-carbon-steel, threaded-shank nails carry the same loads as the corresponding low-carbon-steel nails.

5 The use of high-carbon steel for and hardening of the smaller-diameter nail are as effective in increasing nail efficiency at ultimate loads immediately after joint assembly as proper shank-threading of the larger-diameter, same-length, low-carbon-steel, plain-shank nail.

6 Smaller-diameter, hardened high-carbon-steel, plain-shank and threaded-shank nails carry, at design deformations, one-tenth larger loads than the corresponding same-length, low-carbon-steel nails. Thus design data for low-carbon-steel nails can be used for the corresponding same-length, hardened high-carbon-steel nails.

SUPPLEMENTARY TESTS

Conclusions from additional tests on joints similar to those previously described may be advanced as follows:

1 Low-carbon-steel, plain-shank nails carry approximately one-half larger loads at 0.015-in and 0.030-in joint deformations than helically threaded Stronghold Screwnails† in three-member non-prebored and prebored, dry southern pine joints.

2 Clinching has no effect on the lateral load-carrying capacity of low-carbon-steel, plain-shank nails and Stronghold Screwnails at proportional limit and at 0.015-in and 0.030-in joint deformations of three-member, prebored dry southern pine joints.

3 Low-carbon-steel, plain-shank and helically threaded Screwtite nails carry approximately the same loads at 0.015 and 0.030-in deformations in three-member, green southern pine joints.

4 Low-carbon-steel Screwtite nails carry approximately one-fourth larger loads at 0.015 and 0.030-in deformations than Stronghold Screwnails in three-member, green southern pine joints.

APPLICATION OF FINDINGS

On the basis of data given in the Wood Handbook (2), the lateral load at proportional limit for one 0.135-in-diameter by 2½-in-long low-carbon-steel, plain-shank nail in average southern pine of 15 per cent moisture content is 109 lb. On the other hand, the design data as suggested in the National Design Specification (1) is 131 lb, or 20 per cent larger than the Wood Handbook data. Both these loads are to be decreased by 25 per cent, that is, to 82 and 98 lb, respectively, if this nail is used in green wood (1, 2).

In the tested southern pine having a moisture content of 26 per cent, the corresponding average load for this nail at 0.015-in joint deformation is 100 lb. Thus this test result is in direct agreement with the design data suggested in the National Design Specification. Since the interchangeability of proportional limit load and load at 0.015-in joint deformation is feasible (6), the presented test information substantiates the validity of the respective design data as advanced in the National Design Specification. However, this specification does not provide information on important factors that should be given consideration in the design of nailed joints, such as (a) nails loaded in double shear, (b) optimum nail diameter, and (c) effect of time on lateral load-carrying capacity.

Based on the tested joints, low-carbon-steel, plain-shank and threaded-shank nails loaded in double shear carry twice the respective single-shear loads. This relationship between single and double-shear loads is in agreement with German design specifications (3). The tests also show that double-shear load does not amount to twice the single-shear load, if the nail is not of optimum diameter for the given joint. Thus double-shear loads for the 0.203-in-diameter by 4-in-long low-carbon-steel, plain-shank and threaded-shank nails are only 1½ times the single-shear loads.

Under certain conditions, the effect of delayed lateral loading on the load-carrying capacity of plain-shank nails results in a 30 to 40 per cent decrease in lateral load-carrying capacity at 0.015-in joint deformation, although little or no decrease may be observed for ultimate loads (6). Whenever design for nails in lateral loading cannot be based on ultimate, the given decrease in lateral load-carrying capacity of plain-shank nails at design deformation may be detrimental to the nailed structure. The presented data are based on tests performed immediately after joint assembly, and those data on plain-shank nails must be given consideration in light of this condition. As with plain-shank nails, delayed (in comparison with immediate) lateral loading has no effect on the lateral load-carrying capacity of helically threaded Screwtite nails at ultimate loads (7, 8); however, data are not available on the effect of delayed lateral loading of threaded-shank nails at 0.015-in joint deformation.

The National Design Specification does not contain design data for hardened high-carbon-steel nails. Since double-shear loads are only slightly larger than single-shear loads for the tested hardened high-carbon-steel, plain-shank and threaded-shank nails, the same relationship between double shear and single shear does not apply to nails of low-carbon and hardened high-carbon steels. However, the hardened high-carbon-steel, plain-shank and threaded-shank nails carry, at 0.015-in joint deformation, one-tenth larger grand average loads than the corresponding same-length, larger-diameter, low-carbon-steel nails. Hence, on the basis of the limited number of available test data, the design loads for low-carbon-steel nails also may be applied to the corresponding same-length, hardened high-carbon-steel nails.

Although hardened high-carbon-steel nails cost more than the corresponding same-length, low-carbon-steel nails, they have several advantages. They are not as susceptible to rusting. They weigh less. Less steel is needed to make the smaller-diameter hardened nail than the corresponding low-carbon-steel nail. The smaller shank diameter of the hardened nails results in easier nail driving. The stiffness of the hardened nails allows straighter driving, and thus reduces the number of nails led out by the grain of the lumber. This stiffness also may make it possible to drive these nails into dense hardwoods without preboring. The smaller shank diameter causes less splitting of the wood with a resulting increase in joint strength. More hardened high-carbon-steel *(Continued on page 486)*

Engineering Developments and Challenges in Chemical Weed Control

By Earl D. Anderson
MEMBER ASAE

BETTER control of weeds has been a constant challenge to the agricultural engineer. The average annual loss due to weeds in the United States is estimated by the Department of Agriculture at $5 billion. Dr. E. P. Sylvester, 1951 president of the North Central Weed Control Conference, states it another way; he says that next to soil erosion, weeds cause the greatest single loss to agriculture today. Weeds have been a problem not only to the agricultural engineer designing equipment specifically for weed control, but to the designers of other machines such as crop harvesters and to the engineers concerned with problems of conditioning and storage of grain and the design and maintenance of drainage and irrigation ditches.

At a meeting of the American Society of Agricultural Engineers in St. Louis, Mo., in June, 1946, Kephart (1)* described a new chemical weed killer of extraordinary potency called 2,4-D. He suggested that "anyone interested in the machinery end of agricultural engineering would do well to keep a weather eye on developments in the herbicide field during the next few years." Two years later at the ASAE annual meeting at Portland, Ore., the situation with respect to equipment for applying weed control chemicals was reviewed in a series of three excellent papers. Suggestions were given for the design of equipment for applying 2,4-D based on the limited research and field experience at that time, but what is the status now?

Current Status. We have seen great progress in this field in the past four years. Chemical weed control has proved to be a profitable farm practice and has been widely adopted. There are counties, in which weeds constituted a major agricultural problem, where now as many as 95 per cent of the farmers own their own equipment for applying weed-killing chemicals. In 1951, 30 million acres of crop and pasture land were treated with weed-control chemicals. Twenty-three million pounds of 2,4-D alone were used last season and the USDA predicts that 28 million pounds will be used in the 1952 crop season. This same source indicates that approximately 53 per cent of this material is applied in the north central states, 29 per cent in the Rocky Mountains and western states, 16 per cent in the South and 2 per cent in the northeast and Atlantic states. The $57 million output of the sprayer and duster industry in 1950, representing a tenfold increase in ten years, reflects to a considerable extent the increasing demand for equipment for chemical control of weeds.

Because of the developments in improved chemicals and methods and equipment for applying them, we can quite properly repeat the slogan of the Roberts County, South Dakota, weed control board which states: "It costs more to keep weeds than to control them."

Fifty Years of Weed Spraying. To those who may not be familiar with the history of this type of farm machinery, it may appear that farm sprayers were first developed in the period 1945-50. It is a matter of record, however, that several companies now manufacturing sprayers were organized for that express purpose prior to 1890, and sprayers and dusters have had a long and successful performance record on many farms, especially those specializing in the production of fruit, vegetables and livestock. A search of the literature indicates that sprayers were used for chemical control of weeds fifty years ago, although admittedly changes taking place since 1945 have practically revolutionized not only weed spraying but the entire spraying program in agriculture.

MacDonald (2) mentioned the use of sulfate of iron for weed control in grain fields in the period prior to 1912 in the Great Plains states. H. L. Bolley of the North Dakota Agricultural Experiment Station in 1912, following ten years of experimentation, prepared a station bulletin, entitled "How to Spray Sulphate of Iron", which included these recommendations: ". . . to do the best work apply at least 52 gal (containing 100 lb of sulphate of iron) to the acre . . . the solution must be applied with a powerful spraying machine, producing a real mist, free from drops. The best pressure is 80 to 100 lb, measured at the nozzle, not at the pump." Dr. H. E. Horton, an agronomist, worked closely with what is now the agricultural engineering department at Cornell University in testing and appraising the performance of sprayers used for the application of sulphate of iron in the period 1909-11. As an employee of the American Steel & Wire Co., he also cooperated with the agricultural experiment stations and farmers in the Great Plains area in promoting this practice. However, farmers gradually lost interest in chemical weed control because of the somewhat erratic performance of the limited group of chemicals at their disposal, the necessary high rates of application, and certain limitations of the application equipment then available.

In the 20-year period prior to the introduction of 2,4-D, the use of certain new weed-control chemicals such as fuel oils, acids, sodium chlorate, borax and sinox gradually developed in the grain and commercial truck-growing areas of California and other states as the result of experimentation by chemical manufacturers in cooperation with the agricultural experiment stations. These chemicals were commonly applied at the

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*Numbers in parentheses refer to the appended references.

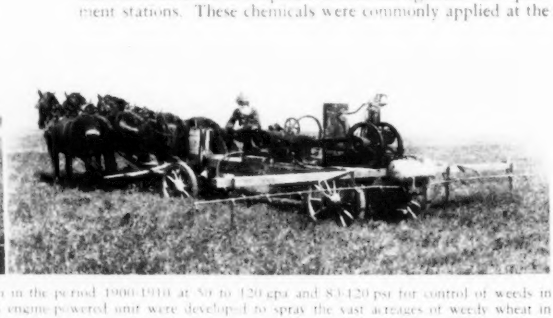

Fig. 1 (Left) Experimental field application of sulphates of iron in the period 1900-1910 at 50 to 120 gpa and 80-120 psi for control of weeds in wheat fields. • Fig. 2 (Right) Special spray rigs such as this engine-powered unit were developed to spray the vast acreages of weedy wheat in the great plain states circa 1910

rate of 80 to 120 gpa and at pressures in the range of 75 to 150 psi.

To apply these chemicals, growers were using many different types of sprayers ranging from 1000-gal-capacity tanks mounted on track-laying chassis and equipped with 40-ft booms capable of covering 120 acres per day, to small converted orchard sprayers with small rotary pumps of the type used for forest fire control, powered by the fan belt of the transporting truck. Despite the large scale use of these chemicals in certain areas, they were used for the most part over the country as a whole for spot control of noxious weeds which were required by law to be controlled.

Enter 2,4-D. Then came 2,4-D. This new growth-regulating chemical, a product of wartime research, was immediately hailed as a most promising and useful new addition to the current list of weed-killing chemicals and attracted much farmer interest even at the first recommended application rates of 80 to 160 gal per acre, the common spraying rate. Experimental work in 1946 showed that equally effective results could be obtained with this new chemical at application rates of 2 gpa and lower, and field tests at several of the agricultural experiment stations in 1947 showed satisfactory results with applications at the more practical farm application rate of 5 to 10 gal per acre. Farmers short of help and chemical manufacturers anxious to expand this new market were quick to see the potentialities of this revolutionary new development. It appeared that 2,4-D would not only control some weeds which cultivation methods only spread, but the economics of this operation looked good — spraying would return a good profit. In short order the relative merits of butyl esters and amine salts and tractor-mounted and trailer-type sprayers became the subjects of everyday barnyard discussions.

The manufacturers of sprayers were unable to completely meet this sudden and unprecedented demand for equipment for weed spraying. Production during the war had been greatly restricted and they now held a vast backlog of orders for regular equipment to be produced with limited supplies of materials. This attracted new manufacturers and many small shops in rural areas, with war contracts suddenly cancelled, quickly "tooled up" for sprayer production. Also plans were prepared in feverish haste by chemical manufacturers, state agricultural colleges and others for a weed sprayer the farmer could assemble based not on what would do the best spraying job or provide for possible future needs but what would require a minimum of scarce materials and would meet minimum requirements for applying 2,4-D. The principal component parts called for in this sprayer assembly usually consisted of a low-gallonage, low-pressure, rotary-type pump to be powered by the tractor power take-off or belt pulley, a pressure relief valve and pressure gage, a three-section boom equipped with low-gallonage nozzles, the necessary shutoff valves, line strainers and connecting hose. Because of the critical steel shortage, the tank was to be supplied by the user, who usually secured one or more 55-gal used steel drums for the purpose. Plans were also furnished for constructing the brackets for attaching the tank or tanks and the boom to the tractor. Agitation was furnished by by-pass from the pump. Thus the tractor-mounted, tractor-powered weed sprayer had its beginning. Then a very extensive educational program was organized. Group meetings wre held throughout the country with the state agricultural extension services, chemical manufacturers, and sprayer manufacturers cooperating to assist the farmers with this new problem.

Many farmers were later to find that this weed sprayer was a limited-use machine when they discovered, with typical farmer ingenuity, that they had many other profitable jobs for a sprayer around their farms. In most cases, however, where it operated successfully, the sprayer in one year's operation brought sufficient increased profits through weed control to pay many times the original cost of the machine and the chemical used. These early sprayers, therefore, served a useful purpose in introducing the new practice of chemical weed control on thousands of farms throughout the country and paved the way for the more ready acceptance and use of a host of new weed and other pest-control chemicals which were soon to be introduced.

Low-Gallonage Spraying. This new low-gallonage concept of field spray application, which called for a new precision in manufacture and field operation of sprayers and which reduced by as much as 90 per cent or more the amount of water as a diluent to be handled based on previous spraying standards, has been a major development of our time. It was responsible for a reappraisal of many problems in the control of harmful insects and plant diseases leading to economical means of large-scale control for the first time of such pests as grasshoppers, corn borers, green bugs, and many others attacking field crops.

We should not overlook the important service performed during this period by the agricultural engineers in many of the state agricultural experiment stations and the U.S. Department of Agriculture in working with the agronomy and botany departments in the development of more suitable equipment for test-plot application. Some of the early controversial research results following the introduction of 2,4-D could quite probably be attributed to many variables resulting from nonuniform application of the chemical.

Mass Field Test. The changes in design leading up to the present-day models of sprayers were influenced by the results of what was probably the greatest unscheduled mass farmer field trial of new farm equipment ever undertaken. Many problems were brought to light by this field test and various corrective measures have been applied.

Nozzle clogging at the 5-gpa rate was a common complaint in the early days. In some sprayers replacing strainers with finer mesh openings solved the problem. Changing the nozzle size from 5 gpa to 10 or 15 gpa proved to be a practical solution adopted by many manufacturers. Chemical producers also contributed greatly by changing to improved formulations. The introduction of replaceable nozzle tips resulted in a savings to the farmer and further increased the flexibility of use of his equipment.

Weaknesses in spray booms have been eliminated by several means. The use of the new eyelet-type nozzle connection

Fig. 3 *(Left)* The introduction of 2, 4-D and its successful application by means of tractor-mounted, tractor-powered sprayers at 5 to 10 gpa inaugurated a new era in the control of weeds and in agricultural spraying in general • Fig. 4 *(Right)* Skid-type, 50-gal, multipurpose sprayer is easily transported on tractor, trailer or truck for field spraying

corrected one common weakness — the source of fatigue failure of single-member tubular booms. A combination boom with a strong structural member to support a separate feed line of rubber hose or brass for the spray material was used by other manufacturers as materials became more readily available.

Pump failures were too frequent on these early models. Sprayer manufacturers have eliminated many unsuited types and the use of larger capacity pumps with improved sealed bearings to eliminate leakage and with moving parts made of better materials contributed to better performance. Farmers and dealers also learned by experience the limitations of different types of pumps with respect to operating pressures and types of materials they would handle. For example, gear pumps would not satisfactorily handle wettable powders, whitewash or other abrasive materials. The piston-type pump has recently been adapted for tractor power-take-off operation as a means of increasing the range of spray materials which can be applied. This is the same type of pump which has been used successfully for many years on other spray equipment. The diaphragm-type pump has also been recently introduced to the power-spraying field and adapted for power-take-off operation. Its ability to handle abrasive materials in the pressure range under 80 lb is well known suggesting increased use in this field.

Hose and gaskets made of synthetic rubber resistant to oils and chemicals are now standard equipment on practically all sprayers used for weed control, thus eliminating what was once a major source of trouble.

Some of the early brackets used for mounting tanks and booms were difficult to attach and remove. As a result some farmers failed to spray their weeds at the proper time. New tractor-mounted units commercially produced for the most part now include improved bracket design, reducing the time of attachment to a matter of a few minutes. Another approach to this problem was the development of the trailer-type unit which is quickly made ready for use by attachment of trailer hitch to drawbar and mounting of pump and control valves on the tractor. Some trailer units are powered by a self-contained, air-cooled engine adapting the unit also to stationary spray work.

CONTROL OF FLOW OF LIQUIDS TO THE BOOM

Control of flow of liquids to the several segments of the boom or to the hand gun is made easy by the development of a new manifold type of control valve currently produced by several manufacturers.

The tractor speedometer, also new, makes possible a much more precise rate of application of weed-killing chemicals, serving as a guide to prevent overdosing which is costly and may be harmful and underdosing which may be ineffective.

Single-nozzle-type booms have been developed which provide a coverage of 10 to 50 ft or more. Although uniformity of coverage is believed to be subject to the effects of wind velocity and direction this type nozzle may prove useful where extreme accuracy of coverage is not required such as for roadside and right-of-way spraying and possibly other uses.

Multiple Purpose Sprayers. The need for a more versatile type of sprayer for farm use was indicated shortly after the introduction of 2,4-D, when DDT was shown to provide effective control of European corn borers then building up in great numbers and in control of farm flies. Berge (3) has indicated the various farm jobs for which Wisconsin farmers can profitably use sprayers and discussed the pump capacity, pressure and other requirements for handling various types of spray materials. As materials became more readily available there was a renewed interest in the conventional orchard sprayer. A new multiple-purpose model farm sprayer incorporating many of the basic features of the orchard sprayer was the result. The heart of the new unit was the positive-displacement, reciprocating-type piston or plunger pump consisting of one or two cylinders with a capacity of 5 to 8 gpm and developing pressures of from 250 to 400 or even up to 800 psi. Mechanical agitation was provided because this type of pump could successfully handle the wettable powders and water-base paints which required special tank agitation. These sprayers are produced with tank sizes ranging from 50 gal to about 250 gal or more and mounted on skids or wheels. They are powered either by a self-contained, air-cooled engine or by a power take-off shaft connected to the tractor. Standard equipment includes field boom and hand gun with a length of hose. The small skid models are sometimes mounted on a platform on the rear of the tractor. The wheel-mounted units of course are ready for instant use by mere attachment to tractor drawbar. These units are still greatly outnumbered by the tractor-mounted, tractor-powered units, but being soundly engineered to meet the wide variety of farm spraying problems, they are certain to become increasingly popular as the farmers gain more spraying experience. The farm tractor passed through a stage when many engineers were drawing plans for converting automobiles into tractors.

Self-propelled, high-clearance sprayers developed in the past few years primarily for control of insects on market, canning, and hybrid seed corn are currently used to some extent for weed control particularly to control those weeds left standing after the last cultivation.

Hand Equipment. Hand equipment is playing an increasingly important part in the farm chemical weed-control program. This is especially true on farms where large fields of noxious weeds have been reduced to small patches and can more easily be controlled by the smaller equipment. Many farmers today mount the compressed air or knapsack sprayer, filled with weed chemical, on their tractor where it is handy for instant use as they pass patches of weeds needing spraying on their way to and from field work.

COMPRESSED AIR SPRAYER MADE IN VARIOUS SIZES

The compressed air sprayer is now made in various sizes from 1½ to 5 gallon capacity. Some models are available with rechargeable CO_2 cylinders which eliminate hand pumping. Sprayer carts are available for transport of the larger size compressed-air sprayers thus lightening the job of hand operation. The knapsack sprayers, with a capacity of 4 to 6 gal, are now available with side-lever operation or telescoping-type pumps. Most of these hand units are now produced with oil and chemical-resistant hose and gaskets. Adjustable nozzles are available to cover a wide range of weed-spraying operations. When equipped with a multiple-nozzle hand spray boom, these hand sprayers make short work of spraying fence corners or weed patches left in fields following the last cultivation.

The Challenge to Agricultural Engineers. Certain mistakes have been made in this chemical weed-control program — some very expensive ones. Perhaps they can be avoided or at least minimized in the future if the new problems are subjected to sober, sound engineering analysis. Let us rather be right than just first.

What are the challenges of the future? I would list the major ones as follows:

1 The design of equipment which will satisfactorily resist the corrosive, abrasive and other deleterious effects of the wide range of weed and other farm-control chemicals as well as those to be marketed tomorrow has posed a real problem to the sprayer manufacturer. And of course a spray chemical on the dealer's shelf which cannot be satisfactorily applied is of little help to the farmer. I am glad to report that a coordinated research attack on these problems is now under way and preliminary progress reports look very encouraging.

2 Design of simpler, more effective and more economical pumps.

3 Functional design of long-life nozzles with greater attention to particle size and pattern developed.

4 Arrangement of all working parts into a more compact and practical mounting for tractors in the case of tractor-mounted, tractor-powered units.

5 We have concentrated on the problems of 2,4-D applications perhaps at the expense of other useful weed-control chemicals, some of which offer the greatest opportunity for eliminating hand weed hoeing and thus completely mechanizing the production of additional field crops. Some of these chemicals have proved to do a better job than 2,4-D on specific applications. We should therefore not overlook these other useful chemical tools. *(Continued on page 486)*

Selecting Rear Tires for Farm Tractors

By J. W. Shields
MEMBER ASAE

THE problem of selecting the right tires for the rear of a farm tractor is not a simple one as these tires must perform the triple function of carrying the weight of the machine, transmitting the power of the engine and providing the traction for pulling the load. The problem is made more complex because the tires may operate in a wide variety of soils varying from light dry "roller bearing" sand to heavy clay and moist cover crops.

The chief purpose of the tires is to pull a load, and carrying the weight of the tractor is only secondary. The rubber tire industry has never had a rule or formula that could be used to determine the pulling ability of tires and for selecting the right size and type of tires for a tractor to be operated in a certain type soil.

The Tire and Rim Association has set up "load and inflation" tables and these are very useful in determining the maximum load a tire can carry at a given inflation pressure; but they are of little help in determining the proper tires for a given tractor, as there is no tractor made that is heavy enough to provide the required traction without the addition of extra weight on the rear tires. As a result of this, it is common practice to increase the tractor weight by adding cast-iron wheel weights and filling the tires with water or calcium chloride solution.

In order to determine the expected performance of rear tractor tires, five factors must be considered. These five factors are (1) engine horsepower, (2) operating speed, (3) soil charactristics, (4) tire load, and (5) inflation pressure.

The forward force of a tractor can be computed, from horsepower and the travelling speed, or miles per hour (mph), by the formula:

$$\text{Pounds forward force} = 375\ \text{hp} \div \text{mph}$$

The forward force determined by this formula is of course theoretical and does not take into account the power losses in gears, bearings, tires, and soil. Tests have shown that in heavy clay about 80 per cent of the engine power is delivered to the drawbar and in dry sand almost half the power is expended in moving the tractor, leaving only about 55 per cent for useful work to pull the load. The ratio between the theoretical forward force and the actual drawbar pull is called the "tractor efficiency" and may be expressed by the following formula:

$$\text{Efficiency} = \text{drawbar pull} \div \text{forward force}$$
$$\text{or Drawbar pull} = \text{forward force} \times \text{efficiency}$$

The traction or pull a tire can develop depends on the load it carries or how hard it is pressed against the ground. For example, a tire operating in average loam soil will pull about half as much as the weight it carries. If a tire operating in loam carried 2,000 lb, it would pull about 1,000 lb. The ratio between the weight carried and the pull is called the "coefficient of traction" and can be expressed by the formula:

$$\text{Coefficient of traction} = \text{drawbar pull} \div \text{tire load}$$
$$\text{or tire load} = \text{drawbar pull} \div \text{coefficient of traction}$$

The coefficient of traction varies with different soils and both the efficiency factor and the coefficient of traction will vary widely for a given soil depending on whether the soil is loosely plowed or hard packed, and also with the moisture content and cover crop. In most soils both of these factors are low when the soil is very dry and increase with additional moisture up to a certain point, then decrease as the soil be-

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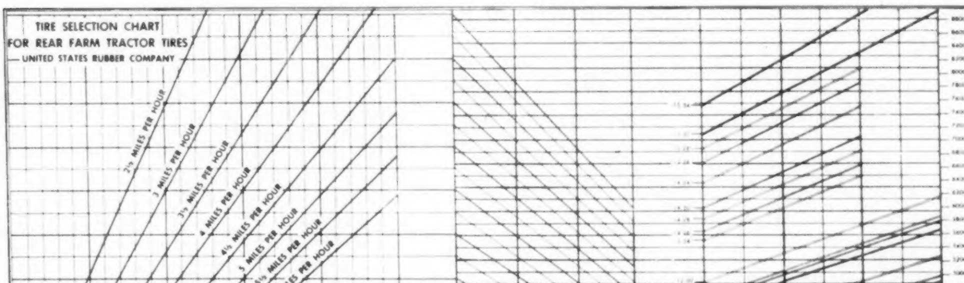

comes "wet". The following figures must be considered only as average or comparative:

Type of soil	Efficiency factor	Coefficient of traction
Clay	0.80	0.65
Loam	0.70	0.50
Sandy loam	0.65	0.40
Dry sand	0.55	0.30

The above three formulas can be combined into the following formula:

$$\text{Load on two rear tires} = \frac{375 \text{ hp} \times \text{efficiency}}{\text{mph} \times \text{coefficient of traction}}$$

The "load on two rear tires" as determined by this formula is that which they must carry in order to provide adequate traction in the given soil to transmit the full power of the engine at the chosen operating speed without excessive tire slippage. The correct size, ply rating, and inflation pressure of tires can be determined from the load figure as computed above by referring to the Tire and Rim Association's load and inflation tables.

TIRE SELECTION CHART

The accompanying "Tire Selection Chart" was developed from the above formula using the coefficient of traction and efficiency factors given above. In order to use this chart it is necessary to know (1) the available horsepower of the engine, (2) the type soil on which the machine will be used, and (3) the speed at which the tires are expected to transmit the available power of the engine.*

The following example will illustrate the use of the chart:

Suppose we have a tractor with an engine that develops 35 hp and a "plow gear" to operate at 4½ mph. We want to find what tires would transmit the full engine power at 4½ mph on loam soil, without excessive slippage.

The solution of this problem is illustrated by the dotted line on the chart. Start at 35 hp at the lower left side of the chart. Follow the dotted line up until it comes to the diagonal line representing "4½ mph". From this point, follow the dotted line to the right and down the slope to the line which represents "Loam soil", then horizontally to the right to the column of tire sizes.

The tire sizes above the dotted line, such as 12-26, 11-38, 12-28, 11-42, etc., are adequate and may be used with a pressure of 12 lb per sq in.

If the tires below the dotted line are used, they should be inflated to more than 12 psi. To find the correct pressure for these tires, follow the dotted line to the right until it crosses the lines representing the tire sizes, and then refer to the pressure shown at the bottom of the chart. The 11-28 would require 14 psi; the 10-38, 15 psi, and the 11-24 would take 16 psi.

The "ply rating" is indicated by the type of line as shown at the lower right corner of the chart. For this problem, the 12-26, 11-38, and 12-28 tires above the dotted line would be 4-ply rating. The "ply rating" of tires below the dotted line is indicated where the dotted line crosses the "tire line". The 11-28, 10-38 and 10-36 would be 4-ply rating, but the 11-24 should be 6-ply rating.

To determine the amount of weight required on the rear end of the tractor, follow the dotted line to the extreme right where the figures show the "Weight on two rear tires". For this problem, it is 3730 lb. This weight figure includes weight of tractor, wheel weights, liquid ballast, weight of operator and allows for "weight transfer"†.

*Tires commonly used on farm tractors will not hold the full power of the engine in low gear. They are usually considered adequate if they will transmit the full power in "plow gear" which is generally between 4 and 5 mph.

†The "weight transfer" for different commercial tractors varies from about 15 to 25 per cent of the drawbar pull. The "rear end weights" shown in the accompanying chart allows for 20 per cent weight transfer.

Chemical Weed Control

(Continued from page 484)

6 There is a need for further development in the use of directional spray equipment and probably for the use of shields to protect the pay crop.

7 There is a challenge probably more to the chemical manufacturer than to the engineer to develop a satisfactory cleaner and indicator for use in decontaminating equipment to be used for applying other sprays on sensitive plants. The use of a tomato plant as an indicator requiring a day or two for reading is hardly compatible with other developments in the spraying program to anyone who has used litmus paper.

8 Increased attention should be given to the special problems in a closely allied field, that of applying brush-control chemicals.

Faced with feeding and clothing an ever increasing population on an almost static crop-production acreage, current emphasis is properly placed on getting higher yields from existing acreages by better farming methods and bringing back into production land lost to a growth of underbrush. The use of modern weed and brush-control chemicals applied by modern methods and equipment will play an increasingly important part in agricultural production. The job is far from finished; in fact, we are told this chemical age has just begun. Agricultural engineers have much to contribute in this further development.

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Nailed Trussed Rafters

(Continued from page 481)

nails may be driven into the same-size joint with equal or less tendency toward splitting. In consideration of these advantages, it is probable that hardened high-carbon-steel nails will be used more than in the past, particularly since notably less effort may be expended by the workman in joint assembly.

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Some Effects of Rim Width on Tractor Tire Performance under Four Conditions

By E. G. McKibben, I. F. Reed, and C. A. Reaves
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THIS is a report of results obtained by a project sponsored by the Tire Industry Test Committee* and conducted by the USDA Division of Farm Machinery at the Tillage Machinery Laboratory, Auburn, Ala. A major objective of this project was to determine whether or not there is justification, in terms of increased drawbar pull or improved efficiency, for the widespread tendency of operators to use rims wider than those supplied as standard by the tire industry.

SUMMARY

From the standpoint of the primary objective of this project, the following conclusions cover the more important phases of this report.

1 For the four traction conditions tested, there was no significant difference in the performance of 14-26-in, 6-ply, tractor tires when mounted on 12, 14, 16, and 18-in rims and operated at the same inflation pressure, with the same total load on each tire.

2 With these 14-26-in tires filled with water to the top of the rim and no compensating weight added, the tire load (for two tires) was about 240 lb more with 18-in than with 12-in rims. Even on dry sand this additional weight will support at least an additional 100 lb of drawbar pull.

3 Compared to the standard inflation pressure of 12 psi, the lower inflation pressure of 8 psi gave better efficiency and about 15 per cent greater drawbar pull for a given travel reduction when operated on dry sand with the same static load, 3,120 lb, per tire. However, this lower inflation pressure caused what appeared to be excessive wrinkling of the side walls of the tires but with this wrinkling less pronounced for the tires mounted on the wider rims.

4 Endurance tests are needed to determine whether, for a given service life of tires, wider rims will permit operation at lower inflation pressures.

TIRES AND RIMS

The tires used were 14-26-in, 6-ply, both button type, R-3, and bar type, R-1 (Fig. 1). Both types of tire were tested on 12, 14, 16, and 18-in rims. For these tires the Tire and Rim Association recommends a 13-in rim as standard, and the 12 and 14-in rims as alternates.

Careful measurements were made of the inflated but unloaded diameter and maximum width of both types of tires on the four widths of rims. Measurements were also made of the cross sections of button-type (R-3) tires on the four widths of rim under a static load of 3,120 lb and inflation of 12 and 8 psi†. The data from these measurements are shown in Fig. 2.

INFLATION PRESSURES AND TIRE LOAD

The recommended inflation pressure, 12 psi, and static load per tire, 3,120 lb, were used for all but two of the seven series of tests of this project. A lower pressure of 8 psi was used for two of the three series of tests of the button type (R-3) tires on dry sand. One of these lower-pressure series was run with the 3,120-lb static load per tire recommended for 12 psi inflation and the other with a reduced static load per tire of 2,160 lb.

Since the Tire and Rim Association does not list inflation pressures below 12 psi, the tests at 8 psi are admittedly lower than approved by the industry. The tests at 3,120 lb static load and 8 psi inflation caused excessive wrinkling of the side walls.

It should be noted that the dynamic load on the tire, that is, the load when operating, is increased above the static load by the amount of the so-called "weight transfer" caused by the moment of the drawbar pull. For the tests reported here the dynamic load on the tires was equal to the static load plus 0.2 of the drawbar pull.

SOILS

Four test surfaces were used, Lakeland sand‡, Hiwassee sandy loam§, Decatur clay loam, and medium rough finished concrete. Mechanical analysis, plasticity index, bulk density,

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*The authors wish to acknowledge valuable suggestions and guidance received from members of the Tire Industry Test Committee and also the assistance received from Glenn E. Coppock and other members of the staff at the Tillage Machinery Laboratory.

†A pressure of 12 psi is the lowest inflation pressure recommended by the Tire and Rim Association.

‡Listed as Norfolk sand in earlier reports.

§Listed as Davidson loam in earlier reports.

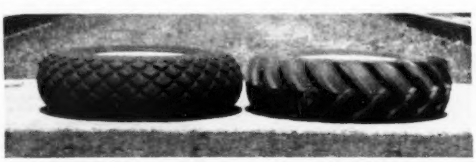

Fig. 1 Tractor tires, 14-26 in, 6-ply, button type, R-3, *(left)* and bar type, R-1 *(right)*, mounted on 12-in rims

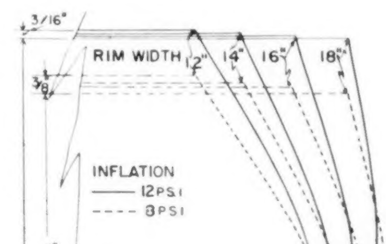

Fig. 2 Cross section of button-type (R-3) tires, shown in Fig. 1, under static load of 3120 lb at recommended inflation pressure of 12 psi and at a lower pressure of 8 psi

and moisture content of these soils at time of tests are listed in Table 1.

The sand plot was prepared with a cross-tilling machine equipped with cultivator shovels running 8 in deep and with a

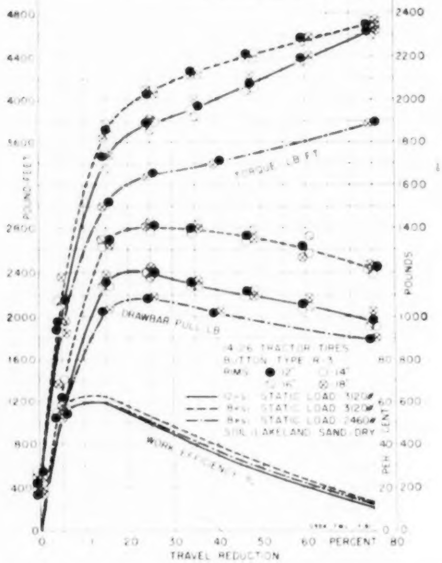

Fig. 3 Travel reduction, torque input, drawbar pull, and work efficiency for 14-26-in, 6-ply, button-type (R-3) tires mounted on 12, 14, 16, and 18-in rims and operated on dry sand with inflation pressure and static load as indicated. Dynamic load on tires was equal to static load plus 0.2 of drawbar pull. Each point plotted is the mean of values obtained by four tests of a single tire. The values shown for drawbar pull are higher than would have been obtained with a rear-wheel-drive tractor by the amount required to roll a front wheel

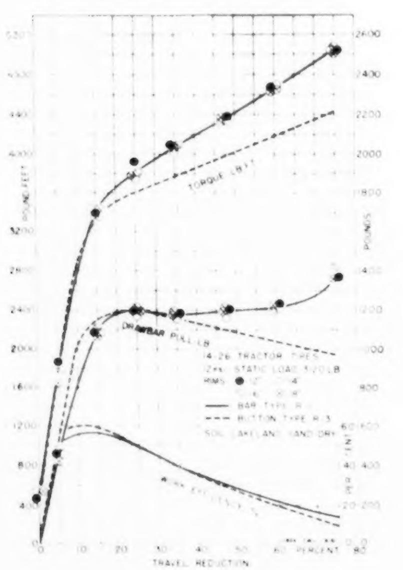

TABLE 1. SOILS USED IN TESTS

Series	Sand (a) per cent	Silt (a) per cent	Clay (a) per cent	Plasticity index (b)	Bulk density		Moisture, per cent	
					[illegible]	[illegible]	[illegible]	[illegible]
Lakeland sand (d)	[illegible]	[illegible]	[illegible]	(e)	[illegible]	[illegible]	[illegible]	[illegible]
Hiwassee sandy loam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Decatur clay loam (f)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(a) Determined by Bouyoucos hydrometer method
(b) Difference between per cent moisture at lower plastic and lower liquid limits
(c) Dry basis
(d) Listed as Norfolk sand in earlier reports
(e) Nonplastic
(f) Listed as Decatur loam in earlier reports

suspended leveling bar. This machine covered the entire width of the test area. Thus it tended to eliminate the differences in soil preparation across the plot which are inherent in the use of narrow soil preparation tools operated the long way of the plot. In preparing the sandy loam and clay loam test plots, a deep cultivator and a subsurface packer were used in addition to the cross-tilling machine.

The test plots were protected from rain by cover cars

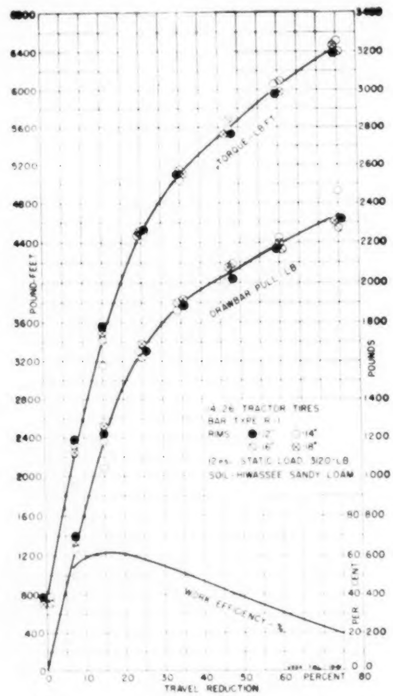

Fig. 5 Travel reduction, torque input, drawbar pull and work efficiency for 14-26-in, 6-ply, bar-type (R-1) tires mounted on 12, 14, 16, and 18-in rims when operated on sandy loam at 12-psi inflation and static load of 3120 lb. Dynamic load on tires was equal to the static load plus 0.2 of the drawbar pull. Each point plotted is the mean of values obtained by four tests of a single tire. The values shown are higher than would have been obtained with a rear-wheel-drive tractor by the amount required to roll a front wheel

Fig. 4 Travel reduction, torque input, drawbar pull, and work efficiency for 14-26-in, 6-ply, bar-type (R-1) tires mounted on 12, 14, 16, and 18-in rims and operated on dry sand at 12-psi inflation and 3120-lb static load. Dynamic load was equal to static load plus 0.2 of drawbar pull. Each point plotted is the mean of values obtained by four tests of a single tire. The values shown for drawbar pull are higher than would have been obtained with a rear-wheel-drive tractor by the amount required to roll a front wheel. Broken line curves for button-type (R-3) tires were taken from Fig. 3

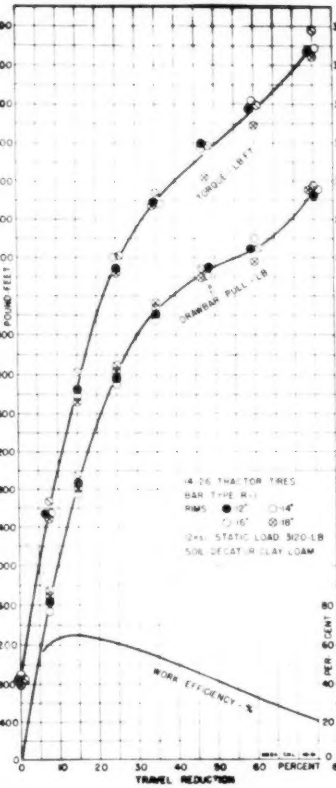

Fig 6 Travel reduction, torque input, drawbar pull, and work efficiency for 14-26-in, 6-ply, bar-type (R-1) tires mounted on 12, 14, 16, and 18-in rims and operated on clay loam at 12-psi inflation and 3,120-lb static load. Dynamic load was equal to static load plus 0.2 of drawbar pull. Each point plotted is the mean of the values obtained by four tests of a single tire. The values shown for drawbar pull are higher than would have been obtained with a rear-drive wheel tractor by the amount required to roll a front wheel

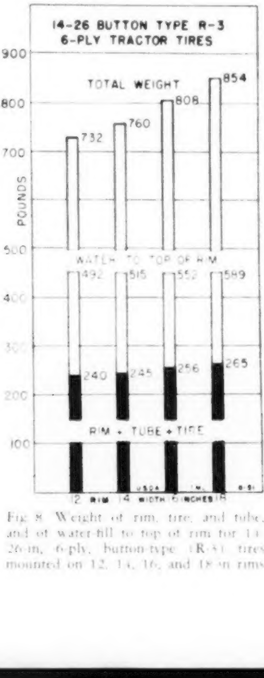

Fig 8 Weight of rim, tire, and tube, and of water-fill to top of rim for 14-26-in, 6-ply, button-type (R-3) tires mounted on 12, 14, 16, and 18-in rims

which were kept on the plots except when they were being prepared or used for tests

TEST PROCEDURE

The static load on the test tire was kept constant by adding or removing weights from the tractor to compensate for differences in the weights of the rims. Inflation pressure was

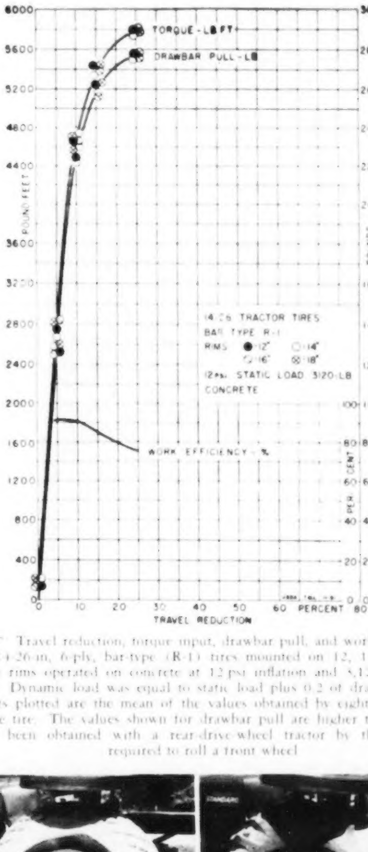

Fig 7 Travel reduction, torque input, drawbar pull, and work efficiency for 14-26-in, 6-ply, bar-type (R-1) tires mounted on 12, 14, 16, and 18-in rims operated on concrete at 12-psi inflation and 3,120-lb static load. Dynamic load was equal to static load plus 0.2 of drawbar pull. Points plotted are the mean of the values obtained by eight tests of a single tire. The values shown for drawbar pull are higher than would have been obtained with a rear-drive-wheel tractor by the amount required to roll a front wheel

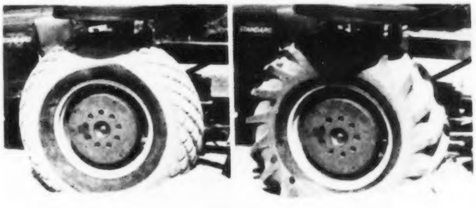

Fig 9 Dig-in on dry sand by one-half revolution at zero travel of 14-26-in, 6-ply, button-type (R-3) tire (*left*), and 14-26-in, 6-ply, bar-type (R-1) tire (*right*) under 3,120-lb static load with 12-psi inflation (See Fig 10)

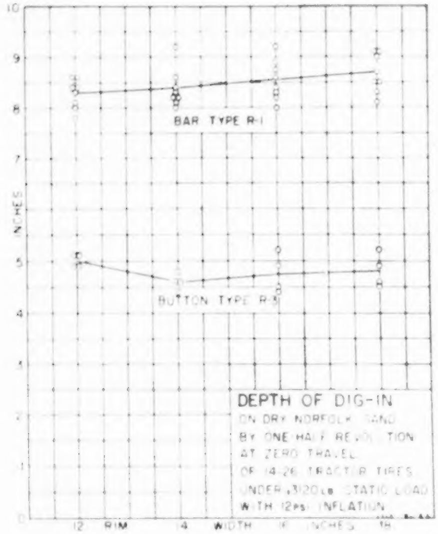

Fig. 10 Depth of dig-in on dry sand by one-half revolution at zero travel of 14-26-in, 6-ply, button-type (R-3) and bar type (R-1) tractor tires under 3,120-lb static load with 12 psi inflation

checked before running each test track. The tractor engine speed was maintained at 1400 rpm which gave a calculated tractor speed of 1.5 mph at zero drawbar pull.

Travel distance for each revolution of the test tire was obtained from a chart operated by a solid rubber-tired wheel running on a test plot rail. This chart was marked by a pen actuated by a solenoid controlled by a cam on the wheel carrying the test tire.

Travel reduction was calculated from the travel distance, thus measured on the basis of the travel distance for the same tire on the same soil, with the same inflation pressure and load, but without drawbar pull. By the use of a travel-reduction meter and a loading generator, tests were run at 5 or 7.5, 15, 25, 35, 47.5, 60, and 75 per cent travel reduction on the three test soils, and at 5, 10, 15, and 25 per cent travel reduction on concrete.

Torque input was obtained by use of an induction-type, strain-gage dynamometer in the hub of the test wheel. A Sanborn amplifier and recorder unit was used to measure and record the output from this dynamometer.

The drawbar pull was measured with an Emery hydraulic cell and a pressure recording unit.

Travel, torque, and drawbar chart recordings were synchronized by the use of magnetically operated pens.

TRACTION DATA

The data obtained for travel reduction, torque input, and drawbar pull, as well as the corresponding work efficiencies, are shown in Figs. 3, 4, 5, 6, and 7. The values given are for only one tire. The values for drawbar pull are higher than would have been obtained with a conventional rear-drive tractor by the amount required to roll a front wheel because rollers with antifriction bearings operating on rails mounted on the test car were used to carry the front end of the test chassis.

It should also be noted that the values given in Figs. 3, 4, 5 and 6 are the mean of four tests and those of Fig. 7 is the mean of eight tests.

These tests indicate the following:

1 No significant differences in the drawbar pull and work efficiency of the 12, 14, 16, and 18-in rims for the four test conditions used — dry, loose sand to concrete.

2 Lowering the inflation pressure of button type (R-3) tires from 12 to 8 psi without changing the static tire load when operating on sand, increased the drawbar pull by more than 15 per cent and appreciably improved the work efficiency. (It should be noted that the Tire and Rim Association does not recommend pressures below 12 psi. See closing paragraph of this report under "Sidewall Wrinkling".)

3 Reducing the static load to 2,460 lb for the 8 psi inflation gave a lower drawbar pull and no appreciable improvement in efficiency compared with results obtained with the rated static load of 3,120 lb and inflation of 12 psi.

4 With button-type (R-3) tires in dry sand, the maximum drawbar pull was obtained at a travel reduction of about 25 per cent and the maximum efficiency at a travel reduction of between 10 and 15 per cent.

5 Bar-type (R-1) tires compared with button-type (R-3) tires, when operated on dry sand, produced lower drawbar pulls and were slightly less efficient below about 25 per cent travel reduction but gave relatively higher drawbar pulls and improved efficiency at the higher values of travel reduction. (See section of this report under "Dig-In".)

6 For the sandy loam and clay loam soils, the drawbar pull increased up to the highest (75 per cent) travel reduction tested. In both cases, however, the maximum efficiency was obtained at about 15 per cent travel reduction.

(Continued on page 496)

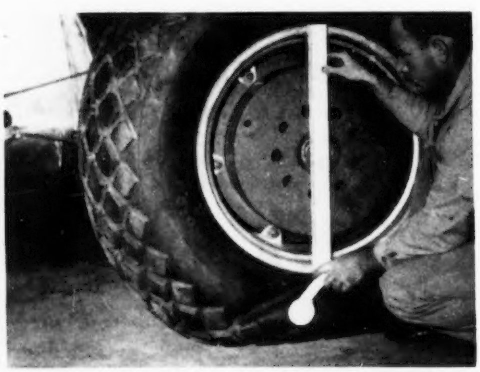

Fig. 11 Measuring wrinkle in center circle of tire sidewall of button-type (R-3) tire mounted on 12-in rim, inflated to 8 psi, and subjected to static load of 3,120 lb and static torque of 2,700 lb-ft

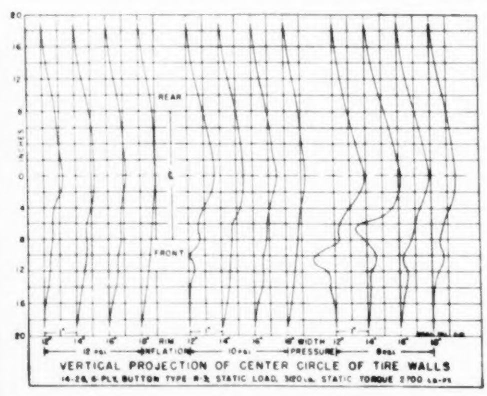

Fig. 12 Vertical projections of center circle of sidewalls of 14-26-in, 6-ply, button-type (R-3) tires under 3,120-lb static load and 2,700-lb-ft static torque when mounted on 12, 14, 16, and 18-in rims and with 12, 10, and 8 psi inflation

Soil Movement by Raindrops

By George R. Free

MOVEMENT of soil by the impact of raindrops is a very old phenomenon which has left marks everywhere without attracting much attention. The marks, ranging from soil on the lower parts of the outside walls of dwellings and sand in freshly picked spinach to actual downslope movement of soil on agricultural fields and the changes in soil characteristics associated with the action of rain, have been observed or studied by many. The actual process of the making of the marks received little attention until fairly recently. During the past few years considerable light, both literally and figuratively, has been focused on the action (6)*.

Reasons for the interest in soil movement by raindrops that has been manifested by agricultural engineers, soil scientists, and soil conservationists need little discussion. My own first close acquaintance with soil splash occurred some 15 years ago when, during the process of measuring the canopy interception of rainfall associated with different vegetative covers, considerable soil was found in the catchment jars under fallow and corn and little was found under close-growing cover. This was a variable accorded little significance at the time, but it was clearly one of the many evidences or marks of soil movement by raindrops.

Investigations which involve the study of soil movement by raindrops have been under way at Marcellus, N. Y., during the past three years. It is the purpose of this paper to present a description and discussion of the technique used and some of the results obtained, and to discuss their application to the more general problems of runoff and soil erosion. The studies were undertaken, not as a study of soil movement *per se*, but as a part of the over-all problem including such factors as exposure, differences in soils, and effects on certain physical characteristics of soil. Much of the work thus far has of necessity been of an exploratory nature.

PROCEDURE

A typical installation of equipment used for measuring the effect of rain is shown in Fig. 1. A pan of soil is on one end of a level board approximately 12 in above the ground. On the inside of the pan and slightly raised off the bottom is a perforated sheet metal plate covered with cotton. This supports the soil, permits free drainage, and prevents the loss of soil in percolate. The pans are 8¾ in long, 5¾ in wide, 2 in high at one end and about 4 in high at the other end. They were constructed from the bottom portions of ordinary 2-gal oil cans.

The soil in all test pans is kept at a moisture level near saturation by a shallow water table on the bottom of the pan. An inverted ½-gal fruit jar at the other end of the board supplies water as needed to replace that lost by evaporation. A tube connects the lid of this jar to the small round metal can shown just to the left of the jar in Fig. 1. An opening in the bottom of the round can is connected to the bottom of the soil pan by the long rubber tube below the board.

When infiltration of rain occurs, the height of the water table tends to rise in the soil pan and in the round can. An overflow opening in the can, slightly above the opening leading to the jar, drains the percolate into the jar sitting on the ground.

Evaporation losses are determined by measuring the change in height of water in the inverted jar. This jar is refilled when necessary. Percolate from each of the pans is stored and used as the first source of water for refilling jars. This means that salts removed in percolate are returned to the soil. Some difficulty was experienced at times because an increase in temperature tended to force water from the jar. This was minimized by refilling the jars frequently, so that the volume of air in the jar was small in relation to the volume of water.

The soils used for the studies are gently sieved at a suitable moisture content through a screen with ⅛-in-square openings to break up lumps and remove coarse gravel and stones. All soils when packed into the pans are air-dry. The pans are filled by distributing soil uniformly over the pan. The excess soil is then scraped off, and the remainder packed by pressing on a board just fitting the pan. The pan is then filled again, and the soil packed into place as before. Finally the surface of the soil near the runoff spout is shaped to direct runoff water into the spout. A drop trough, extending completely across the lower edge of the pan and replacing the spout, was an improvement used after the first year.

DETERMINATION OF LOSSES

The pans of soil are oven-dried after packing. It was thought that this procedure was much better than depending upon moisture samples before and after exposure for calculating oven-dry weights and losses. An accurate determination of losses was considered of greater importance than possible effects upon the stability of aggregates. Losses of soil from the pan occur as wash-off losses, which can be measured for each individul storm, and as splash losses which are obtained by difference for the whole period of exposure.

These pans can be set at ground level (Fig. 2) as well as elevated above it. They can also be faced in different compass directions to determine the effect of slope aspect. The directional setup was used only during the first year and thereafter all pans faced the west only. In order to measure the rain falling on the pans, four empty soil pans facing the four compass points were set up with screens in them and with the bottom openings leading to jars. This procedure was not entirely satisfactory because of the splash loss which occurred despite the screens. Therefore, during the directional studies, the amounts of rain each pan received were calculated from the catch in the vertical openings of a directional gage (Fig. 3), and the catch in a standard gage with horizontal opening using the method described by Fourcade (9). The Marcellus field station is on a modified drumlin, and soil pans and all rain gages were located on the high point of the drumlin where there was nothing to interfere with the free sweep of storms from any direction.

Chief interest in these studies was in the soil loss by wash-off and splash, the amount of percolate, and the condition of the soil after exposure. The evaporation losses, while comparable, were very much greater than would prevail under field conditions. They are regarded as a by-product of the study and have limited application under field conditions.

It has been noted in runoff plot work at Marcellus that the most serious runoff and erosion occurs when rain falls on wet soil packed by previous rains. These studies were conducted under these same conditions with respect to moisture content of the soil. Another reason for maintaining a high level of moisture was to insure that there would be no soil removed from the pan by direct action of wind. During the second year some pans were used without the water table, and because of the fact that frequent storms occurred and the soil was cultivated as soon as possible after rains to close the shrinkage cracks along the sides of the pans, a fair degree of success resulted.

The technique employed appears to constitute a satisfactory test of soil whereby the effects of natural rain may be

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Soil and Water Division. It is also a contribution from the division of research, Soil Conservation Service, USDA, in cooperation with the Cornell University Agricultural Experiment Station. It includes portions of a thesis by the author in partial fulfillment of requirements for the master of science degree, graduate school, Cornell University.

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*Numbers in parentheses refer to the appended references.

studied under controlled conditions. During the first year the only soil used was Honeoye surface soil from the Marcellus Station. This is a highly productive soil derived from limestone till. The second year, several soils were used. These were selected from other areas where experimental work was under way and also from other profiles in New York by Dr. Arnold J. Baur, state soil scientist for the Soil Conservation Service. During 1951, samples of Sassafras soil from various plots at Riverhead, N. Y., were used. Throughout all of the work, the Honeoye has been used as a standard or reference soil.

RESULTS

Directional Series, 1949. Each treatment studied in 1949 was in duplicate. During the period from May 15 through October 15 there were 39 rains that caused percolation from pans of Honeoye surface soil. The totals of rain falling on pans of the elevated directional series decreased in the order west, south, north and east, Table 1. Evaporation (not given) decreased in the order south, west, north and east. In both cases east was smallest, and either west or south was greatest. Evaporation from the pans was from 2.4 to 2.7 times the amount of rainfall.

TABLE 1. INFILTRATION AND LOSSES OF SOIL BY WASH-OFF AND SPLASH

(Elevated pans of directional series, Honeoye soil, May 15 to October 15, 1949)*

Direction of Exposure	Rain, in.	Infiltration inches	Infiltration per cent	Soil loss from pans by wash-off tons/acre	Soil loss from pans by splash tons/acre
West	17.5	7.9	45	0.8	68.7
North	15.5	6.6	42	1.2	60.6
East	14.3	5.4	38	0.6	58.4
South	16.5	7.1	43	0.8	66.6

*Fresh soil May 15, June 22, and September 15.

Only three of the 39 storms gave a greater catch in the east opening of the directional gage (Fig. 3) than in the west. Two of these were small inconsequential storms and one was a heavy thunderstorm which approached from a direction slightly east of north. The pronounced angularity of many of the rains is shown by the fact that the catch in some of the eight vertical openings of the directional gage exceeded the catch in the horizontal gage 10 out of 39 times.

It will be noted in Table 1 that infiltration decreased in the same order as that previously given for the amount of rain. For that reason the differences are less on a percentage of rainfall basis than shown by actual quantities.

There are many evidences in the detailed data that infiltration capacities declined with increasing length of exposure to rainfall. Percentages of infiltration for fresh pans of soil varied within the rather narrow range of 53 to 83. After a few storms there were only a few falling outside a range of 15 to 45. There were two cases where a direct comparison of fresh soil with exposed soil was possible. In one, infiltration as a percentage of rainfall was 83 for fresh soil compared to 19 for exposed soil. In the other, the corresponding percentages were 60 and 26.

Wash-off losses, Table 1, were quite small considering the amounts of runoff. On these small pans there was little opportunity for runoff to concentrate into channels and acquire velocity. Another reason for wash-off losses being so small on the elevated pans was the fact that most of the soil splash did not fall back onto the water leaving the pans as surface runoff. Trends of wash-off with respect to compass direction were not significant but, when all records were arranged in order of catches of rain in the directional gage, differences were significant. The wash-off losses for those pans facing the direction of the storms were about three times those from pans facing away from the direction of storms.

The wash-off losses by individual storms in general showed the usual and expected tendency to vary with the amount of intense rain and rain intensity. There were, however, some rather large intense rains which did not cause appreciable wash-off losses. This may be related to differences in drop size which were not measured but it can also be explained by sur-

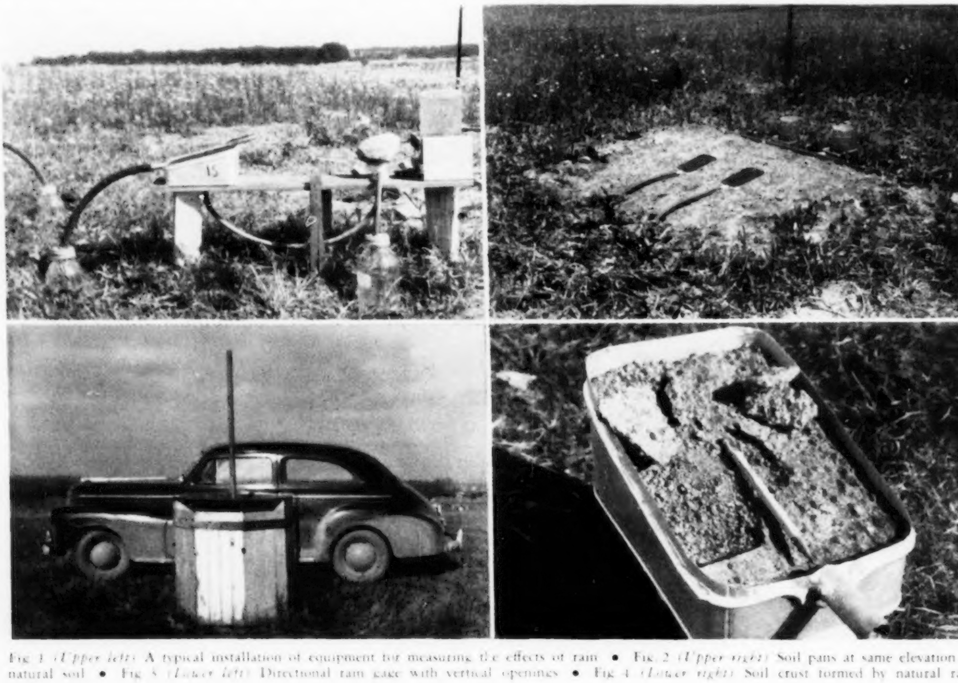

Fig. 1 *(Upper left)* A typical installation of equipment for measuring the effects of rain • Fig. 2 *(Upper right)* Soil pans at same elevation as natural soil • Fig. 3 *(Lower left)* Directional rain gage with vertical openings • Fig. 4 *(Lower right)* Soil crust formed by natural rain

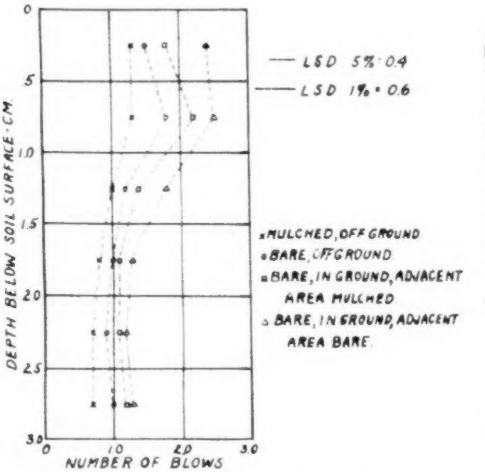

Fig. 5 Variation of penetrability with depth and treatment

face flow since the thicker the film of water running off, the greater would be its velocity and transporting power.

Measurable wash-off losses occurred during only nine storms. The most intense of these occurred on June 25 when 1.17 in fell in 30 min. Four of these nine storms caused small amounts of runoff from field plots on the Station. The field plots were, of course, at field moisture and did not happen to be bare at the time.

The losses by splash from the pans of this directional series were from 50 to 90 times the wash-off losses. Had the movement occurred under field conditions on bare soil of comparable moisture content, some part of the splash loss would have appeared as wash-off loss. Splash losses per storm were not determined, but there is evidence in the detailed data that they tended to be greatest on fresh pans of soil. Losses for the shorter periods of exposure varied from about 5 to 7 tons per acre per inch of rain.

Mulch and Elevation Series, 1949. Another series of pans, also in duplicate, were set up facing the west only. Three treatments ran for the whole period of study, with a change of soil on August 9. These were (a) elevated bare, (b) elevated with a straw mulch of 1 ton per acre, and (c) bare at ground level. A fourth treatment consisting of bare soil at ground level with the area around the pans mulched was started on August 9. The resulting data are given in Table 2.

TABLE 2. EVAPORATION, INFILTRATION, AND SOIL LOSS DATA FOR PANS OF MULCH AND ELEVATION SERIES, 1949

	Evaporation	Infiltration		Wash-off/acre		Splash loss/acre	
	5/15-10/13 Inches	5/15-8/8 Inches	8/9-10/13 Inches	5/15-8/8 Tons	8/9-10/13 Tons	5/15-8/8 Tons	8/9-10/13 Tons
Elevated bare	41.5	2.9	4.8	0.9	0.2	32.0	34.6
Elevated mulched	29.9	4.6	5.4	.3	.1	0.5	0.7
Bare in ground	32.6	1.4	3.9	1.2	.3	22.2	25.9
Bare in ground (area around pan mulched)	—	—	3.4	—	.4	—	28.0

In considering the data for the two different periods, it is important to keep in mind that the amount of rainfall was not greatly different. However, only one of the nine storms causing wash-off losses occurred during the second period. It will be noted that the wash-off losses reflect this difference in rain whereas the splash losses do not.

The mulch reduced evaporation and increased infiltration, particularly under the rain conditions of the first period. The mulch also reduced wash-off losses to about one-third of those occurring from bare soil. The splash losses from the mulched pans were only about one-fiftieth of those from bare soil.

The splash losses from the bare soil at ground level, amounting to about 70 per cent of those from the elevated pans, were much greater than anticipated. Several factors could be responsible for more soil splashing out of these pans than splashed in. The soil in the pans was at a high moisture level, whereas that outside was at field moisture. Also, the bare area around the pans was probably not wide enough. It has been shown by Ellison (6) that particles of soil may be splashed a maximum distance of from 3 to 5 ft. It has also been suggested that the fact that more soil splashed out of the pans at ground level than splashed in is an indication of the effect of soil pretreatment (oven-drying) on splash susceptibility. However, it can also be argued that it may be a measure of the change in splash characteristics of the outside soil associated with the natural drying which occurred between storms.

After the unexpected results were obtained during the first period from placing the pans at ground level, the fourth treatment was started. Actually, as the data in Table 2 show, it contributed little to an understanding of what occurred. Some fraction of the soil splashed from the pan onto the mulch may have been splashed back onto the pan again.

Effects of Soil Characteristics, 1949. Despite the fact that soil splash was free to leave the pan, marked crusting of the soil occurred. The thickness of some of the soil crust is shown in Fig. 4. The soil below the crust was nearly as loose and friable as the original soil before exposure.

Volume weights of the crusts from one set of pans from the directional series are presented in Table 3. The volume weights of these crusts were determined by the paraffin technique (13). The soil had been exposed to less than 3 in of rain over a period of about 5 weeks. These data emphasize the marked effect of rain in compacting the soil surface. One difficulty in working with crusts is that thickness as well as density may differ. Some of the crusts formed during the second exposure period were quite thin and compact and others were thicker but possibly less compact. Those formed during the third and last exposure period were so thin that they could hardly be called crusts and yet they were very effective in reducing infiltration.

A miniature soil penetrometer, consisting of a sharpened nail driven into the oven-dry soil after exposure by dropping a 50-g weight on it from a height of 10 cm, was used for studying the thickness and penetrability of the crusts. This showed that crusting could extend to a depth of 1½ cm, although as previously mentioned it also showed that during the last exposure period the crusts formed were very thin and relatively fragile.

Other volume-weight determinations not presented here showed that mulching reduced the volume weight of crust slightly and also showed that the crusts formed on pans placed in the soil were more dense than those formed on the elevated pans. It is logical to assume that the latter difference is associated with the difference previously noted in net losses of soil by splash. It explains the marked effect of this third treatment on infiltration (Table 2). It does not, however, explain why the difference in splash loss was not greater.

The penetrability of crusts on all of the pans of this series removed at the end of the study was determined by using the nail penetrometer. These data are presented in Fig. 5.

Pan Studies, 1950. A different procedure of replication was used in 1950 to study the splash and erosion characteristics of 10 different soils with three substudies of different past treatments of the same soil. One replicate of each was exposed to natural rain for a period of time and then replaced with another replicate. Previously two replicates were exposed at the same time which meant that fewer soils could be studied with a given number of pans. At first thought the procedure followed in 1950 might appear sufficiently similar to the block layouts used for experimental plots to justify its use. Block

TABLE 3. VOLUME WEIGHTS OF SURFACE CRUSTS ON SOIL

	Crust	Below crust
West	1.38	1.12
North	1.39	1.10
East	1.39	1.06
South	1.39	1.14

and treatment interactions were so great, however, that the procedure cannot be recommended.

Another point to keep in mind too is that a soil sample from only one profile cannot adequately represent a soil type. A series of samples ranging from virgin to an intensively cropped and tilled condition might.

The soils studied ranged in texture from an Ottawa loamy fine sand to the Fulton and Dunkirk silty clay loams. Splash losses from the pans of Ottawa loamy fine sand were high. These pans retained a relatively high infiltration capacity throughout the test. Wash-off losses were low. The splash loss from Ottawa averaged about 8 tons per acre per inch of rain. At the other extreme, the fine textured Fulton and Dunkirk silty clay loams gave large wash-off losses, relatively small amounts of infiltration, and moderate to low splash losses. The Dunkirk is recognized as being one of the most erodible soils in the United States (11).

During the last exposure period a comparison was made of the regular technique and that represented by doing away with the high and constant moisture level associated with the use of the water table. Soils were cultivated as soon as possible after rains. This procedure needs further study, but as a result of these exploratory comparisons, it would appear that both splash and wash-off losses were greater using the modified technique. Percolation was affected greatly, of course, and runoff not nearly so much.

Pan Studies, 1951. During 1951 the only studies made were comparisons of samples of Sassafras soil from Long Island from plots to which wood chips and duck manure had been added for two years and samples from check plots which had received no organic amendments. Pans of the standard Honeoye soil were also used.

The pan test indicated that there had been no significant effects of treatment as yet. This was in agreement with laboratory studies which showed no significant difference in aggregate stability. All of the pans of Sassafras soil gave less percolation, more wash-off (3 to 4 times as much), and less splash losses (about half) than the Honeoye. The splash loss from Honeoye averaged about 7 tons per acre per inch of rain.

DISCUSSION

The movement of sand or soil by raindrops is a spectacular process when closely observed. It can lead to movement of soil downslope. Were it not for the complicating factor of wind action, the movement downslope would be qualitatively similar to that resulting from most tillage operations as described by Mech and Free (10). If one is interested chiefly in the movement, the factor of distance is as important as the quantity of material moved. Some of the material may be moved at one time only a short distance and some as much as 5 ft (6). The amount of work or energy involved in the movement is the summation of the products of weights and associated distances of travel.

The methods of controlling splash movement resulting from natural rain on a given slope fall into three classes. The first and most important is that represented by interposing a protective cover of growing vegetation or mulch between the rain and the soil. The second is to change the physical structure of the soil, and the third is to manipulate the water status of the soil. None of these can be changed appreciably without at the same time altering the infiltration characteristics of the soil. This in turn will determine to a large extent whether the added hazard of water running down the slope will be present to help the splashed particles travel much easier and further than they would through the action of splash and gravity alone. Here we have a complex pattern of movement that under field conditions would be difficult to study even where enough movement has occurred to permit measurements of removal and accumulation. Loss from an area is not the same as movement on the area. On laboratory models the movement could be studied by the procedure used in the tillage study referred to above and expressed in proper units such as foot-pounds.

Studies of splash can be simplified by using inert material such as sand whose splash characteristics will not change greatly providing it presents a level surface and the surface does not fall below the level of the container (2). The statement has been made, however, that the kinetic energy imparted to splashed sand represents only 2 per cent of the kinetic energy of the raindrops (5). This is an important observation and one that probably should be checked further using both sand and soil. One wonders what happens to the other 98 per cent with sand. With soil, however, the assumption that a sizable portion of the energy goes into aggregate breakdown and compaction seems reasonable. Either of these will affect infiltration capacity.

The major part of our attention should be directed towards what happens to soil during the splash process rather than how much soil is moved by splash. Baver (1) has called attention to a conclusion reached by Wollny more than 70 years ago that the major effect of vegetation upon the properties of soils is due to the protective influence of the canopy against the impact of the raindrops. Duley (4) found that infiltration was greatly affected by whether a surface seal associated with the action of raindrops was present or absent. Aggregate breakdown by raindrop impact has been reported by Ellison (6). Ellison and Slater (7) found that infiltration was correlated with the amount of soil in splash.

Those familiar with the shattering of air-dry and oven-dry aggregates that may occur when they are immersed directly in water during wet sieve analyses may be disturbed by the use of oven-dry soil in these tests. No quantitative studies were made of the effect of different soil pretreatments. However, it is important to keep in mind that in these tests aggregates were wetted by capillarity from the water table rather than by immersion or by application of water to the surface. Others (12) have shown that the moisture adjustments resulting from storing air-dry aggregates or by wetting them by very fine spray or capillarity gives high aggregation values (comparable with those obtained in samples at field moisture) even though the air-dry and oven-dry aggregates shatter when immersed.

SOIL WAS EXPOSED TO NATURAL RAINFALL

In this study soil was exposed to natural rainfall over varying periods of time so that cumulative effects could be studied. A high percentage of runoff could be expected since soil moisture was maintained at a constant and high level. The wash-off losses undoubtedly contained some soil that had been moved by splash since some of it fell back onto the pans and either remained or was carried away by flowing water.

The smallness of the elevated pans and the magnitude of the measured splash losses meant, however, that a large percentage of the soil moved by splash left the pan. Despite this removal, marked sealing and crusting occurred. The volume weights of the crusts were much greater than those of the soil below. The penetrability data suggests that compaction extended to a depth below the crust. The crust itself resulted from a combination of compaction, aggregate breakdown, and infiltering of fines. The mechanism of crusting or sealing needs further study. Other workers (3, 8), primarily interested in soil crusts, have emphasized the filtering out and deposition of fines at the surface. This may not be a requisite for sealing, however, since Duley (4) discussed the development of a seal on pure sand.

As a satisfactory degree of erosion control is approached, more rather than less attention should be given to degree and stability of soil aggregation. Erosion control, through reduction of losses of organic matter and the finer mineral particles entering into aggregation, will help to promote aggregation. However, the cropping system and other factors of management should also be such as to insure stable aggregation and a satisfactory structure when soils are exposed. Soil splash, aggregate destruction, crusting and sealing can and do occur without erosion and, in fact, without natural rainfall where sprinkler irrigation is practiced. If fines are responsible for sealing, there should be more attention in aggregate studies to the amount, rate of production, and nature of fines resulting from aggregate instability.

Attention to aggregation and stability of aggregates coupled with additional protection provided by vegetation or residues will in most cases not *(Continued on page 496)*

Air Conditions In and Near Farm Buildings

By Earle F. Cox
MEMBER ASAE

MANY of the discrepancies in the development of ventilation of farm buildings can be related to inaccurate evaluation of the condition of the intake and the exhaust air. Instruments for the measurement of dry-bulb temperatures have been quite accurate, but neither relative humidity nor dew-point temperature instrumentation has been satisfactory. As much variation as ±5 per cent with most instruments for measuring relative humidity has had to be "tolerated" by the investigator.

Of note also is the curious condition that many investigators go to considerable trouble and lengthy calculations to develop the condition of the intake air for a poultry house or other structure, and then will *assume* that the exhaust air maintains a relative humidity of 80 per cent. If the figure assumed to be 80 per cent is actually 75 per cent, the removal of the moisture from the building would probably be impossible. However, if the true condition were 85 per cent instead of 80 per cent, then the ventilation might be adequate or even excessive.

In 1949, the University of Massachusetts acquired electronic equipment for measuring dry-bulb and dew-point temperatures. With this equipment, research was begun to determine:

1 Dry-bulb and dew-point temperatures on the north side versus the temperatures on the south side of a building

2 The effect of removing air close to the ceiling versus the effect of removing air near the floor.

3 Dry-bulb and dew-point temperatures of exhaust air

4 Effectiveness of exhausting air by intermittent periods.

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The results of the first study are presented here. The other three studies will be reported in subsequent articles.

It is known that solar radiation raises the dry-bulb temperature of the air on the south side of a building. The object of the research was to find out whether both the dry-bulb and dew-point temperatures were affected and whether or not the differential between the north and south sides of the building would be sufficient that it would always be desirable to introduce intake air from the south side. Figs. 1 and 2 are charts of records obtained from February 4 to 26, 1951.

The sensing elements for the tests of outdoor air conditions were located approximately 12 in from the building and were protected with a shade. They were located adjacent to a grain room at one end of the building. An integration of the charts indicates that on the south side of the building the average dew point was 24.29 F as compared to an average of 24.65 F on the north side of the building. The inaccuracy of the instrument at ±1½ per cent of full scale could be greater than this difference in dew-point temperatures. However, the figures do indicate that the dew point of the air on the south side of the building will remain very close or equal to the dew point on the north side of the building even though the dry-bulb temperature on the south side increases.

The average dry-bulb temperature on the south side of the building for this period was 30.80 F, while the north side dry-bulb temperature average was 28.62 F. If this differential of 2.2 deg were maintained constantly, it seems that there would be little choice between the intake air location. However, examination of the chart reveals that during certain periods of the day the dry-bulb temperature differential between the north and south sides of the building was as much as 20 deg. The cumulative differential in favor of south-side intake indicates that warmer, drier air should be utilized whenever heat and moisture balance are critical as in poultry-house ventilation.

Investigation of weather data indicates also that during the period of this test the amount of solar radiation was far below normal. The hours of bright sunshine were only 33.5 per cent of the possible hours of bright sunshine; the normal for this

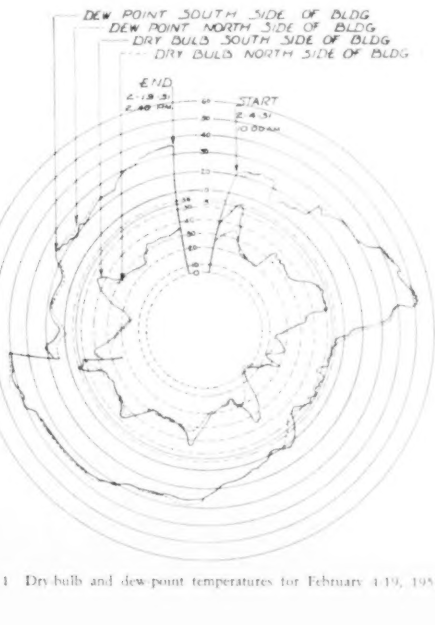

Fig. 1 Dry-bulb and dew-point temperatures for February 4-19, 1951

Fig. 2 Dry-bulb and dew-point temperatures for February 19-26, 1951

period is 53.4 per cent. An even higher differential between the dry-bulb temperatures on the south side and north side of the building should be expected as an average condition than occurred during the test. It also seems evident that the differential in this test can be improved in those regions that have more than 50 per cent of possible hours of bright sunshine.

CONCLUSIONS

1 Little difference between dew-point temperatures of the air on the north side and on the south side of a building is to be expected.

2 Solar radiation can increase the dry-bulb temperature on the south side of a building as much as 20 deg more than that on the north side.

3 For winter ventilation, air intake from the south side is more favorable to control critical heat and moisture balances.

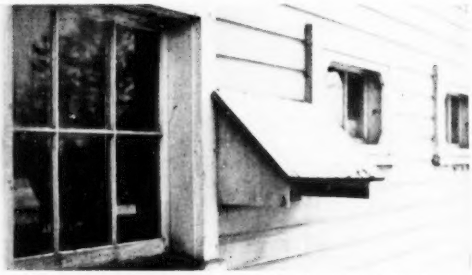

Fig. 5 Location of sensing element with reference to the building

Tractor Tire Performance

(Continued from page 490)

7 On concrete the drawbar pull also increased up to the highest (25 per cent) travel reduction tested. In this case, however, the maximum efficiency was obtained at a travel reduction of less than 10 per cent. (Tests were not run at higher values of travel reduction because of excessive tire wear.)

WEIGHT OF WATER FILL

The increased weight of an 18-in rim, tire, and water over a 12-in rim, tire, and water was 122 lb, or 244 lb for a tractor so equipped (see Fig. 8).

Thus if liquid ballast is used and no compensating weight is added to tires mounted on the narrow rims, this extra weight would provide additional pull with the wide rims.

"DIG-IN"

One of the outstanding differences between the performance of button and bar-type tires on sand was the more rapid "dig-in" of the latter as the per cent travel reduction was increased. In order to make a controlled comparison, the following procedure was used: (a) The test tire was lifted from the soil, (b) the test car was moved to a new location, (c) the test tire was lowered to the soil surface and its elevation measured, and (d) the test car brakes were locked and the test tire rotated one-half revolution and its elevation again measured (see Fig. 9).

The data obtained by this procedure on sand are shown in Fig. 10. The "dig-in" for the button-type tires was only about 56 per cent of that of the bar type. Bar-type tires have a drawbar pull advantage at high travel reduction (Fig. 4) far beyond the normal working range but have the disadvantage that they dig easily into a complete stall.

SIDEWALL WRINKLING

It was readily observable that sidewall wrinkling at high drawbar pulls and the lower inflation pressures was less for the wider rims. In order to reduce this observation to physical measurements, the button-type (R-3) tires mounted on 12, 14, 16, and 18-in rims were subjected to a static load of 3,120 lb and a static torque of 2,700 lb-ft and the wrinkles measured with a micrometer gage as shown in Fig. 11. This procedure was used for three inflation pressures, 12, 10, and 8 psi. The data obtained are shown in Fig. 12. These data indicate a definite decrease in depth of sidewall wrinkles as the rims are widened.

Movement by Raindrops

(Continued from page 494)

entirely eliminate the movement and damage to soil from raindrops, but it will help to control both.

SUMMARY AND CONCLUSIONS

A technique used at Marcellus, New York, for studying the effect of natural rain on soil kept at a constant and high moisture level has been described and discussed. Slope aspect in relation to direction of the storm was shown to be an important factor determining amount of wash-off losses. The losses from pans facing the direction of storm were found to be three times those from pans facing away from the direction of storm. Most of the storms approached from a westerly direction and all showed considerable angularity of fall.

Under the conditions of this experiment, splash losses from elevated pans of bare Honeoye soil were from 50 to 90 times wash-off losses. The average loss per inch of rain amounted to from 5 to 7 tons per acre. A straw mulch reduced splash loss to one-fiftieth that from bare soil and wash-off losses to one-third.

A marked decrease in infiltration occurred despite the fact that most of the splashed soil left the pans. Crusts and thin surface seals were formed which had volume weights of about 1.4 compared to 1.1 or less for the soil below the crusts.

Some differences in characteristics of soils used in the study were noted. The technique used, however, did not allow splash into the pans so that a high rate of particle movement by splash is not necessarily associated with a high erosion rating. The wash-off losses and infiltration characteristics seemed to be more closely related to field behavior than were the splash losses. In fact, the wash-off losses and effects upon the soil remaining in the pans seemed to provide a better index of the erosiveness of storms than did the splash losses.

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Sprinkler Irrigation Research in Canada

By W. L. Jacobson

RESEARCH in sprinkler irrigation in Canada is comparatively new for the most part, but includes projects in the engineering, agronomic, and economic fields of study. Work is under way, or is being organized, at no less than nine federal experimental farms or stations across Canada, and at one or two provincial agricultural colleges.

Canada is well on the way to catching up with the demand for information on sprinkler irrigation. This demand, it may be of interest to note, reached a peak late in 1949, and to meet this need, a review of the work under way was made early in 1950 by the Sprinkler Irrigation Committee for Western Canada.

On the basis of information then available, the Committee agreed that sprinkler irrigation had come to Canada to stay and that it would likely have a place under at least four conditions, including (1) small holdings of up to one and two acres, (2) supplementary irrigation in the dry-land farming areas, (3) supplementary irrigation in the moist areas, and (4) in irrigation farming under certain conditions.

1 *The irrigation of small holdings* does not involve any special research problem and need not be dealt with separately.

2 *The use of supplementary irrigation in the dry-farming and ranching areas* is limited mainly by available water supplies and costs. In the short grass country, feed crops have a high value that is difficult to measure in terms of dollars. However, where used on crops to be marketed for cash, supplementary irrigation becomes strictly a question of costs and returns.

Supplementary irrigation by flooding has been used on the Canadian prairies since the early ranching days, chiefly for feed production. Through the Prairie Farm Rehabilitation Administration water development program, water supplies have been greatly increased by the building of nearly 46,000 individual projects, including dugouts, stock-watering dams, and small irrigation works. These works are mainly for stock watering and domestic use, but the introduction of portable pipe and sprinklers has increased the areas of land that can be irrigated from these individual water supplies and also from existing larger projects where irrigation has only supplementary value.

Surveys showed that the initial cost of equipment for supplementary sprinkler irrigation under prairie conditions varied from about \$5 to \$10 per acre-inch, or from \$20 to \$40 an acre on the basis of 4 in of irrigation. The over-all average was \$34 an acre.

The cost of applying water under these conditions averaged about \$2 an acre-inch, including capital charges and yearly operating expenses. On the basis of about 3.5 in applied to grain and nearly 5 in to pasture land, the total cost averaged from around \$7 to \$10 per acre. Yields of wheat varied, but increases from irrigation averaged about 3 bu per acre-inch of water applied. The margin of increase was not considered sufficient to generally recommend the use of supplementary sprinkler irrigation for wheat, but the sprinkling of pasture land was favored.

3 *Supplementary irrigation in the moist areas* of Canada is used in the Pacific coast region and in eastern Canada.

Sprinkler irrigation of 2-in applications when the soil moisture content reached 20 per cent, proved economical over a period of five years, in pasture studies carried on by the Agassiz Station in the lower Fraser Valley. No increase in yield was obtained in 1948, but in the extremely dry season of 1951, the yield increase from sprinkler irrigation amounted to 2.38 tons per acre, calculated on the basis of dry weight.

Paper presented at a conference on sprinkler irrigation, sponsored by the ASAE Subcommittee on Sprinkler Irrigation Research and held during the winter meeting of the American Society of Agricultural Engineers at Chicago, December, 1951.

The author: W. L. JACOBSON, Experimental Station, Canada Department of Agriculture, Lethbridge, Alta.

Some ten horticultural crops and a pasture mixture are included in the sprinkler irrigation experiments started in 1949 at the Saanichton Station on Vancouver Island. As pointed out by Superintendent J. J. Woods, several years' more work will be required before reliable averages or maximum differences can be obtained. Three years' results indicate that the value of irrigation will vary from year to year, depending on precipitation, soil type, soil fertility, the crop and general farm management. Where soil fertility was adequate, sprinkler irrigation gave economical increases in yields of small fruits, bulbs, potatoes, and pasture grass. The effect on size, grade, and quality of product was considered as equally important as yield increase.

Irrigation was applied at the rate of 0.25 in per hr, and most crops received from little more than 3 in to less than 6 in per season. Evidently water is not too plentiful, and it is interesting to note that use is expressed in gallons per acre.

No results are available from the sprinkler projects in the East, since the projects there are just getting under way, and the rainfall during 1951 was evidently sufficient to provide all moisture needs.

4 *The use of sprinklers in irrigation farming* in Canada is confined to the southern interior valleys of British Columbia and the lower precipitation areas of the prairies. Irrigation research to serve these two regions is conducted mainly from the experimental stations at Summerland, B.C., Lethbridge, Alta., and Swift Current, Sask.

The experimental station at Summerland, B.C., has taken a lead in sprinkler irrigation research, and following are some of the main results reported by Dr. J. C. Wilcox, who is directly in charge of the work at Summerland, and applying to conditions in the Okanagan Valley:

1 Under proper management, sprinkler irrigation caused much less erosion.

2 Less water was required in most cases. The saving in sandy loam soil was 30 per cent as compared with furrow irrigation. The saving in water varied from 5 to 15 per cent with heavy soils, and from 15 to 50 per cent on sandy soils.

3 Better soil moisture conditions were maintained, especially with sandy soils and also where the water supply was inadequate for furrow irrigation.

4 Less time and expense were required for the routine of sprinkler irrigation than for furrow irrigation.

5 In many cases, higher yields have been obtained with sprinklers than with furrows. This applied more especially to vegetables and hay rather than tree fruits.

On the basis of results obtained, the use of sprinkler irrigation is recommended in British Columbia where (1) there is evidence of soil erosion, (2) the soil is sandy, (3) the contour is rolling and such that furrow irrigation would be difficult, (4) water is scarce, and where it is desired to wash excess salts out of the soil.

Dr. Wilcox emphasized that the use of steep erodable land for row and cultivated crops is not recommended, even where sprinkler irrigated.

High capital cost is a factor, but under conditions in British Columbia, where holdings are relatively small, the total cost of sprinkling is only a little more than furrow irrigation where pumping is needed to obtain the necessary pressure, and a little less where the pressure is obtained by gravity.

RESULTS OF RESEARCH IN THE IRRIGATION FARMING AREAS OF THE PRAIRIES

Perhaps the main feature of sprinkler irrigation indicated by the studies conducted in the irrigation farming areas of the prairies, is that this method of applying water affords a high degree of control over a wide range of soil type and topography, and without the aid of skilled irrigators, provided always that the wind velocity is not excessive or too changeable.

However, much of the land included in the tests and surveys was well suited to surface irrigation, and it was for this reason, perhaps, that the sprinkler irrigated crops in the irrigation farming areas did not, for the most part, show significant gains in yields over crops irrigated by one of the surface methods.

As was observed in British Columbia, sprinkling compared more favorably with surface irrigation where the soil was very permeable, where the topography was uneven, or where the slope was excessive or very limited.

The main disadvantages of sprinkling, as compared with the surface methods, under prairie conditions include (1) high initial cost, (2) high operating costs, (3) wind interference, (4) the difficulty of handling a fluctuating water supply, and (5) the aversion of experienced irrigators particularly to carrying pipe through muddy fields and wet foliage. Skilled labor was not required, but where land was well prepared, the surveys have not shown any saving of labor with sprinklers.

Economic surveys showed that the capital cost of sprinkler systems purchased by irrigation farmers varied widely, but ranged mostly from $3 to $10 per acre-inch of water applied, and averaged around $4 per acre-inch. Systems designed to deliver up to 12 acre-inches per acre cost about $48 or more per acre, and in the 1950 surveys, the capital invested in sprinkler irrigation equipment on 21 irrigation farms averaged $41 an acre, and $5,248 per farm.

The cost of applying water by sprinkling on the prairie irrigation farms varied mostly from little more than $1 to less than $3 per acre-inch, and in most cases averaged slightly less than $13 an acre. Fixed costs, including depreciation, repairs and interest, made up about 58 per cent of the total cost per acre, and fuel, oil and labor accounted for about 42 per cent, according to surveys conducted by the economics division.

While paying returns were generally reported by sprinkler users on prairie irrigation farms, it has been emphasized that sprinkler irrigation is being introduced during a period of high agricultural prices and high agricultural income. The real test of sprinkler irrigation is likely to come if and when price levels become less favorable for the farmer.

All existing irrigation projects on the Canadian prairies have been developed on lands that have been classified as potentially irrigable by surface methods. Moreover, all projects now under construction or planned for future development are based on surface irrigation.

Unlike conditions in the tree fruits area of British Columbia, where the holdings are generally small, the topography is often steep, and crops normally have a high acre value, the irrigation farm holdings on the prairies are relatively large, the land is generally more suited to surface irrigation, and crops have relatively low acre values. For these reasons, it may be assumed that surface irrigation will continue as the basic method on prairie projects. This view is supported by the fact that land may now be improved on a large scale and at low cost with the earth moving equipment available.

Sprinkling here promises to be most useful as a supplement to surface irrigation for special crops and uses, and for irrigating lands not suited to surface irrigation, where economic conditions permit.

The economic feasibility of establishing irrigation farming, using only sprinkler irrigation, has yet to be determined, except where crops of high per acre value predominate.

SOME RESULTS OF ENGINEERING STUDIES

Most engineering projects on sprinkler irrigation in Canada have been devoted to testing sprinkler equipment under Canadian conditions.

Various kinds of sprinkler heads were included in tests conducted at Summerland, where some of the types on the market were found to be quite unsatisfactory. Others were found to be satisfactory only under certain pressures and at certain spacings. The hammer-action type now generally used in Canada were found to be most satisfactory.

A project is under way at Swift Current, Sask., to determine the water distribution by sprinklers as influenced by wind. This is a matter of interest on the prairies, because of the windy weather that frequently prevails.

Use of the high pressure or hydraulic type of sprinklers was tested at the Lethbridge station during winds of varying velocities. These sprinklers, which required pressures of 80 lb or more, gave satisfactory patterns under calm weather conditions. However, the patterns were greatly distorted by winds of even moderate velocities, while higher wind velocities gave distribution patterns that could scarcely be measured. Consequently this type of sprinkler is not now being recommended for prairie conditions.

Another study made at Lethbridge was a comparison of rotary sprinklers and perforated pipe. Under proper conditions, both systems gave about equally good results. The perforated pipe cost less to install, and with the lower operating pressure the power requirements were less. However, the narrower spread required more labor for moving pipe, and the application of one inch per hour proved excessive for most soil conditions encountered.

SOME AGRONOMIC FACTORS UNDER STUDY

Two main agronomic factors considered in the sprinkler irrigation studies under way in Canada are fertility and the consumptive use of water by crops where sprinkler irrigated.

Sprinkler irrigation tests in the East and far West include complete fertilizer treatments, while projects on the prairies include phosphorous and nitrogen, but no potassium. A number of workers has emphasized the importance of maintaining an adequate organic content in the soil and the value of a cover crop in retaining favorable soil structure, and keeping infiltration rates at the maximum level for the soil type.

The amount of water applied to crops is measured in all of the major sprinkler irrigation tests. However, the most comprehensive consumptive use of water determinations under way or planned are in the Okanagan Valley and on the prairies.

Working in the Okanagan Valley, Dr. Wilcox found that the maximum consumptive use of water by apple trees plus cover crop, ranged from 0.17 in per day with an irrigation interval of 25 to 30 days, up to 0.30 in or higher where the interval between irrigations was 5 to 10 days. According to Dr. Wilcox, the actual plant use by mature apple trees plus cover crop averaged around 0.11 in per day during the heat of summer.

The maximum monthly use of water in the Okanagan Valley varies from 5 to nearly 7 in with irrigation intervals of 30 to 20 days, up to 10 and 12 in with irrigation intervals of 7 to 5 days. This requires a rate of flow of 2.6 to 6.3 Imperial gallons per minute per acre, or about 3.2 to 7.9 U.S. gallons. The total seasonal use in the Valley varies from 20 to 48 in, depending on soil type and prevailing climate.

Only limited data, determined by sprinkler tests, are so far available for the prairies. However, for the time being, results obtained in surface irrigation tests are useful. The total consumptive use for some sixteen crops averaged 17.1 in in 1949 and 1950. The use for individual crops varied widely. Corn averaged 14.5 in, potatoes 15.0 in, oats 16.5 in, sugar beets 16.6 in, sweet clover green manure 17.1 in, wheat 17.8 in, pasture grasses 19.8 in, and alfalfa, it is estimated, used up to 24.0 in of water for maximum yield. The irrigation requirement would be reduced by the total seasonal rainfall, which averaged little more than 5.0 in in 1949 and 1950, but which varies considerably from year to year.

Seasonal use of water data obtained by means of soil moisture tensiometers, gypsum blocks, and fiberglas units, showed maximum requirements of most crops during July. Cereals used nearly 49 per cent of their total requirements during this month. Corn used 40 per cent, and sugar beets used 30 per cent of their total moisture during July. These results would indicate that a sprinkler system with capacity of 6 gpm per acre or more would be needed to provide for peak requirements of cereals under severe drought, and that 4 gpm per acre or more would be needed for sugar beets.

It is perhaps not necessary, in closing, to emphasize again the need for proper engineering and sound economics in considering sprinkler irrigation. However, some reference might be made to the importance of good agronomic practices in order to secure a proper balance of all factors of production.

(Continued on page 500)

PROPOSED ASAE RECOMMENDATIONS

Installation of Lamp-Type, Pig-Brooding Equipment

(NOTE TO ASAE MEMBERS: In view of the rapidly increasing use of incandescent lamps as a source of infrared energy for heating pig brooders, there is need for observing certain safeguards in the installation and operation of infrared and other types of incandescent pig-brooding equipment. To this end the following recommendations, developed by the Committee on Infrared Lamps for Brooding and approved by the Rural Electric Division of the American Society of Agricultural Engineers, at Kansas City, Mo., on June 17, 1952, will be adopted as official ASAE Recommendations unless substantial objection thereto is raised before October 1, 1952. The Committee on Infrared Lamps for Brooding includes R. E. Heston (chairman), National Association of Mutual Insurance Companies; F. W. Andrew, University of Illinois; S. B. Darnell, Wisconsin Electric Power Co.; W. D. Hemker, Westinghouse Electric Corp.; W. J. Ridout, Jr., *Electricity-on-the-Farm* Magazine, and C. E. Worlan, Iowa State College. The following other persons assisted the Committee in the formulation of these recommendations: J. P. Ditchman, General Electric Co.; W. G. Buchinger, The Detroit Edison Co.; C. L. Hamilton, National Safety Council; H. S. Hinrichs, Kansas Power and Light Co.; H. H. Beaty, Edison Electric Institute, and L. G. Keeney, Farmers Mutual Reinsurance Co.)

REQUIREMENTS FOR SERVICE ENTRANCE FOR ELECTRICAL BROODING UNITS

ALL permanent buildings in which lamps are used for brooding should be equipped with a service entrance as required for outbuildings by the local electric codes and the power supplier along with good wiring practices. Such entrances should include adequate ground and approved entrance cabinet (fuse or circuit-breaker type) with adequate capacity to handle the anticipated load.

Portable buildings requiring the capacity of not more than one circuit shall be served from a service-entrance center. Such a service entrance shall be installed as above.

REQUIREMENTS FOR CIRCUITS SERVING ELECTRICAL BROODING UNITS

1 A circuit serving electrical brooding units and equipment should be permanently installed. The convenience outlets should be located within 8 ft of the lamp location and above pen height in accord with good wiring practice.

2 Non-metallic sheathed cable with neoprene or other acid-resistant covering should be used. It should be supported and protected from mechanical injury in accord with good wiring practices.

3 The conductors should not be smaller than No. 12 Awg (American wire gage).

4 Each circuit should be protected by fuses or circuit breakers rated at not more than 20 amp or in accord with local regulations or requirements.

5 The maximum load should not exceed 80 per cent of the rated capacity of the circuit, seven 250-w lamps or a total of 1750 w.

REQUIREMENTS FOR PEN-HEIGHT BROODERS

1 Each lamp should be protected from moisture and mechanical injury by means of a metal reflector or shield of an approved type. The reflector should be large enough to avoid contact with the lamp.

2 A porcelain receptacle of the switchless type should be used, or its equivalent in temperature characteristics.

3 The unit should be suspended by chain, wire or bracket. The conductors leading to the receptacle should not be used to provide support for the lamp unit.

4 The cord to each lamp should have ample protection against moisture and heat and be of not less than No. 18 Awg for single units and not exceed 8 ft in length.

(NOTE: Cord and socket temperatures tested at the Underwriters' Laboratories have been as high as 90 F above the National Electrical Code limit for rubber insulation. Consequently, to prevent deterioration and the development of fire or shock hazards under these conditions a special rubber-jacketed asbestos insulated cord designated as HSJ, must be used.)

5 If suspended over the sow at farrowing time, the lamp should be not less than 30 in above the bedding, or at least 6 in above the standing animal, whichever is the greater distance.

6 When suspended over the pig litter separated from the sow, the lamp may be lowered to a minimum of 18 in above the standing animals being brooded, provided a barricade of sufficient strength to restrain the sow, constructed to pen height, is installed and securely anchored.

REQUIREMENTS FOR HOVER-TYPE BROODERS

1 The requirements for service entrances, conductors, circuits, cords, loads and fuses should conform to those required of Pen-Height Brooders.

2 A mesh similar to hardware cloth with holes not larger than ½ in should be provided to protect the lamp from bedding and animals.

3 A metallic reflector of sufficient depth to suspend the lamp above the hardware cloth should be used.

4 The distance between the bedding and the top of the hover should not be less than 12 in, when a conventional 150-w incandescent lamp is used, or 18 in for a 250-w lamp. If infrared lamps are used, the same recommendations as for Pen-Height Brooders shall apply, i.e., 12 in above animal for a 150-w, and 18 in for a 250-w lamp.

5 The barrier dividing the brooding area from the rest of the pen should be of sufficient strength to restrain the sow, constructed to pen height and securely anchored.

Sprinkler Irrigation Research

(Continued from page 498)

The results so far obtained by workers in Canada would indicate that it is mainly in this field of research that the maximum and most beneficial use of sprinkler irrigation must be determined. These practices include particularly the choice of suitable crops that offer prospects of profitable returns, the use of cropping practices that maintain desirable soil structure, the maintenance of soil moisture at levels that will give the most economical returns, and, finally, the maintenance of soil fertility at levels needed for maximum returns in yields and quality.

ACKNOWLEDGMENTS: This resume has been made possible by the help and cooperation received from agricultural and engineering workers in Canada, who have supplied material used in preparing the paper. Thanks are due especially to Dr. Wilcox, of the experimental station at Summerland, B. C., who has pioneered sprinkler irrigation research in Canada, and to A. E. Palmer, superintendent of the experimental station at Lethbridge, Alta., for his helpful suggestions. Following is a list of workers who contributed material:

M. F. Clarke, senior agronomist, Experimental Farm, Agassiz, B. C.

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R. S. Tait, manager, Rain Bird Sprinkler Mfg. Co. (Canada) Ltd., Vancouver, B. C.

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J. C. Wilcox, plant nutrition, soils and irrigation, Experimental Station, Summerland, B. C.

T. G. Willis, superintendent, Range Experimental Station, Kamloops, B. C.

J. J. Woods, superintendent, Experimental Station, Saanichton, B. C.

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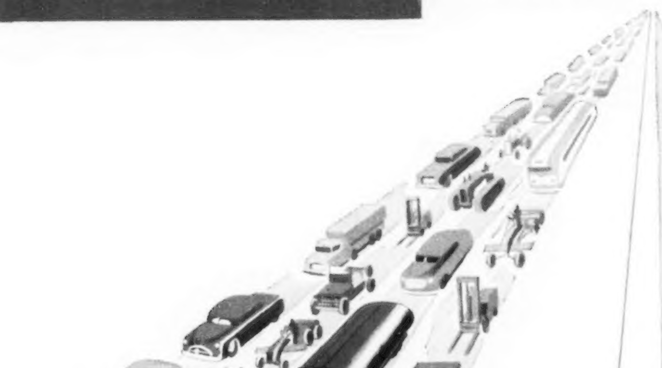

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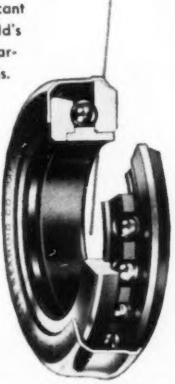

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T-TYPE CLUTCH RELEASE BEARINGS

INSTRUMENT NEWS

KARL NORRIS, Editor

Contributions about interesting agricultural applications of instruments and controls and related problems are invited, and should be sent direct to K. H. Norris, Agricultural Research Center, Beltsville, Maryland.

Thermistors

By J. G. Taylor
MEMBER ASAE

THERMISTORS are "thermally" sensitive "resistors" made from semi-conducting materials. They possess a high temperature coefficient of resistance making them particularly useful as transducers for temperature measurement and control applications.

They also have characteristics of small size, fast response, good stability and high impedance. They require no constant reference temperature and because of their nominal high resistance the length of leads between the thermistor and its associated circuits is usually not important.

Thermistors are presently available in beads small enough (less than 0.02 in.) to be injected with hypodermic needles into living plants and animals to measure internal temperatures. They are also available in the form of rods, disks, washers and as probes (Fig. 1), encased in glass, ceramics and metals.

Fig. 1 A Western Electric type 14B thermistor compared with matches for size, used for general temperature measurement and control purposes. The small black bead at the top of the glass probe is the temperature-sensitive portion. This thermistor has a nominal resistance of 2,000 ohms (± 20 per cent) at 25 C and a temperature coefficient of resistance at 25 C of approximately −0.04 ohms per ohm per degree Centigrade

Thermistors may be used in any circuit sensitive to resistance changes. Because of self-heating, the current through the thermistor should be kept low so that their power-sensitivity rating (0.1 to 20 milliwatts depending on type, size and surroundings) is not exceeded. The measuring circuit generally used for highest accuracy is a d-c Wheatstone bridge circuit although a-c bridges, ohmmeters and vacuum-tube voltmeter circuits may be used.

The resistance-versus-temperature characteristic of thermistors is a logarithmic-type relationship with a temperature coefficient of resistance (per degree Centigrade at 20 C.) as high as −4.4 per cent. Nominal resistance at 30 C ranges between 5 and 500,000 ohms with the different type thermistors. Upper temperature limits are about 300 C.

For thermometric use an individual calibration curve is usually required. Because thermistors have a temperature coefficient of resistance ten times greater than platinum, measurements with a simple Wheatstone bridge circuit and a galvanometer whose sensitivity is 2×10^{-10} amp per mm per m will readily indicate a temperature change of 0.0005 C.

Thermistors are particularly adapted for vacuum-tube temperature controllers. They are usually used in an a-c or d-c bridge circuit, the output of which is connected directly to an amplifier or control tube. By using two matched thermistors in a bridge circuit, a differential temperature indicator or controller* may be constructed, or, similarly, by shielding one thermistor and not the other, a system sensitive to infrared radiation will result. For such applications, thermistors may be purchased in matched pairs.

The author: J. G. TAYLOR, farm electrification division (BPISAE), U.S. Department of Agriculture.

*Yung, F. D. and Soderholm, L. H. Differential Thermostats for Agricultural Applications. AGRICULTURAL ENGINEERING, April, 1952.

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Smith, O. J. M. Thermistors, Part I Static Characteristics, Part II Dynamic Characteristics. *Rev. Sci. Instruments*, vol. 21, no. 4, April, 1950, pp. 344-56.

Technical information on applications of thermistors may also be obtained from the following manufacturers and distributors:

Friez Instrument Division, Bendix Aviation Corp., 1400 Taylor Ave. at Loch Raven Blvd., Baltimore 4, Md.

Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.

Victory Engineering Corp., Springfield Road, Union, N. J.

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NEW BULLETINS

Green Crop Water Requirements for Optimum Growth, by P. L. J. Ryall, C.S. 16, National Institute of Agricultural Engineering (Wrest Park, Silsoe, Beds, England). An interesting brief correlation between rainfall and potential transpiration for various agricultural areas of Great Britain.

Lighting for the Farmstead, by I. P. Blauser. Ohio (Columbus) Agricultural Extension Bulletin 328 (December, 1951). A 30-page summary of essentials and desirable features of wiring and lighting fixtures for the farmstead, including various rooms in the farm home.

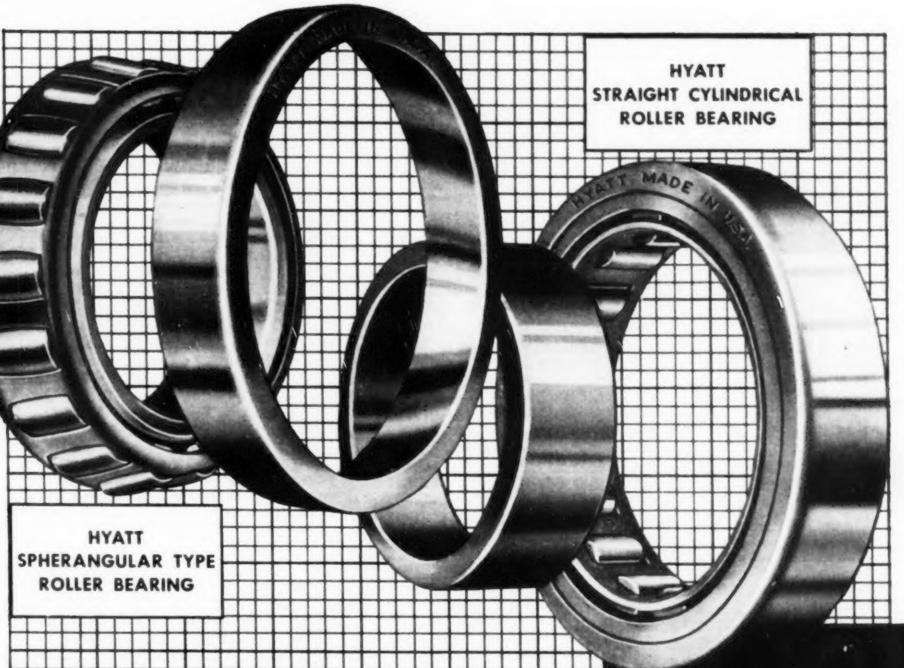
Progress Report on the Wooded Watershed of the Michigan Hydrologic Research Station, by James L. Smith and George A. Crabb, Jr. Article 34-46 (May, 1952) reprinted from the Quarterly Bulletin of the Michigan Agricultural Experiment Station (East Lansing). A 12-page text and graph summary of procedure and results for 11 yr of records, including cumulative precipitation, surface runoff, and soil loss.

The Normal Pattern of Solar Radiation at East Lansing, Michigan, by George A. Crabb, Jr. Reprint of Journal article No. 1144, Michigan Agricultural Experiment Station (East Lansing), from papers of the Michigan Academy of Science, Arts, and Letters, Vol. XXXVI, 1950 (Published 1952). A four-page leaflet summarizing extensive data on the subject.

Lateral and Vertical Pressure of Granular Material in Deep Bins, by Robert A. Caughey, Calvin W. Tooles, and Alfred C. Scheer, Iowa Engineering Experiment Station (Ames) Bulletin 172 (November, 1951). This reports tests and results with wheat, shelled corn, soy beans, cement, sand and pea gravel as to coefficients of friction on concrete, angles of repose, and ratios of lateral to vertical pressure.

Wood Conservation Bibliography, by J. Hugo Kraemer. Domestic Commerce Series No. 30, Office of Industry and Commerce, U.S. Department of Commerce (Washington 25, D. C.). Price 40 cents. An 8¼ x 10¾-inch booklet of 77 pages, with items listed in groups under the subheadings of Production and production equipment, Construction and products, Wood needs and market outlets, Physical properties and uses of native woods, Foreign woods, Value of research programs, Veneer, plywood and laminates, Moisture relations and seasoning, Durability and preservative treatment, and Utilization of wood waste.

Cracking the Midwest Claypan Problem at the Soil Conservation Experimental Farm, McCredie, Mo. Soil Conservation Service, U.S. Department of Agriculture (Washington, D. C.) and Missouri Agricultural Experiment Station (Columbia) unnumbered bulletin (May, 1952). A non-technical report and interpretation of research calculated to be of value to farmers with claypan soil problems.


HYATT
STRAIGHT CYLINDRICAL
ROLLER BEARING
HYATT MADE IN U.S.A.
HYATT
SPHERANGULAR TYPE
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Close-Ups of 1952 ASAE Annual Dinner at Kansas City, Mo.

(*Left view*) Charles J. Scranton (left) is awarded the 1952 Cyrus Hall McCormick gold medal by ASAE President Stanley Madill at the Society's annual dinner June 18. Mrs. Scranton is seated at left. • (*Right view*) President Madill awards 1952 John Deere gold medal to Ivan D. Wood (right), as master of ceremonies, K. W. Anderson, looks on

(*Left view*) The 1952 Farm Equipment Institute trophy, won by the Purdue Student Branch of ASAE, is turned over to Dale Reed (right), official representative of the Branch, by ASAE President Madill • (*Right view*) Stanley Madill brings to a close his term as President of ASAE with the inauguration of Ivan D. Wood as the new President of the Society for the 1952-53 Society year

Part of the group students — members of Student Branches of ASAE from several states — who attended the Society's annual dinner on June 18

NEWS SECTION

North Atlantic Section Maine Meeting Program

RECENT agricultural engineering progress in Maine is recognized by arrangements of the North Atlantic Section, American Society of Agricultural Engineers, to meet at the University of Maine, Orono, August 25-27. It will be the regular yearly meeting of the Section, which has developed into a major event for agricultural engineers included in its membership.

Copies of the printed program are being sent to Section members, and will be furnished others on request to the ASAE headquarters Office, St. Joseph, Mich.

Meeting headquarters will be West Hall on the University of Maine campus. Registration will open there at 2:00 p.m., Sunday, August 24, and continue until 8:00 p.m. that evening. At 8:00 p.m. a reception and mixer will be held at the Louis Oakes Room in the Library Building.

Registration will be resumed at 8:00 a.m. Monday for late arrivals.

General programs are scheduled for Monday and Tuesday mornings, and Wednesday afternoon. Major branches of agricultural engineering subject matter are booked for attention during Monday afternoon and Wednesday morning session periods.

Other features of the program include a tour to the seacoast on Tuesday afternoon, the business meeting of the Section on Wednesday afternoon, and the Section Dinner, Wednesday evening.

The Hon. Clifford McIntyre, businessman, farmer, and Member of Congress from Maine, will address the Section at its dinner.

A. D. Longhouse, West Virginia University, chairman of the Section, will call the meeting to order Monday at 10:00 a.m. in the Library Building. Following his opening remarks he will introduce President A. A. Hauck, University of Maine, who will officially welcome the group.

An outlook on "Agricultural Engineering Research" by E. G. McKibben, BPISAE, U.S. Department of Agriculture, is next on the program. It is to be followed by a presentation of "Challenges Ahead," from an industrial viewpoint, by Karl Butler, Avco Mfg. Corp.

This session will close with announcements by F. W. Peikert, University of Maine, chairman of the local arrangements committee.

During Monday afternoon one session will feature related interests of the power and machinery and the soil and water fields, while a concurrent session directs attention to mutual interests of the farm structures and rural electric groups.

The first named of these sessions will convene at 2:00 p.m. in the Plant Science Building, with H. E. Gray, Cornell University, and S. L. Tallman, Massey-Harris Co. jointly presiding as program committee representatives of the related subject matter fields.

G. E. Ryerson, Soil Conservation Service, U.S. Department of Agriculture is to present a "Progress Report on Stubble Mulch Tillage for Eastern United States," as the opening contribution to the program.

"Traffic Soles" will next be introduced as an item of mutual interest, by George R. Free, Soil Conservation Service, U.S. Department of Agriculture. His contribution will be followed by one on "Liquid Manure Conservation and Use," by J. T. Reid, West Virginia University.

After a seventh inning stretch the program will continue with Hugh Wilson, Cornell University, reporting on "Experiments in Tillage Methods for Loosening Hard Pan Soils," and a presentation on "Krilium," by Roland A. Struchtmeyer.

At the same time in another room of the same building, J. R. Dodge, BPISAE, U.S. Department of Agriculture, will preside over a session featuring mutual farm structures-rural electric interests.

It will open with H. H. Ota, BPISAE, U.S. Department of Agriculture, giving a "Report on Research in Poultry Calorimeter." "New Ideas in Poultry Housing" are scheduled to be reviewed by Glenn O. Bressler, The Pennsylvania State College.

"Preliminary Results from Greenhouse Using Solar and Electric Heat" are to be reported by M. O. Whithead, Atlantic City Electric Co.

A guest speaker from beyond the Section area, Carl Boester, Purdue University, will be the fourth speaker. His subject will be "A New Sewerless Toilet for Farm Use."

R. H. Wileman, United Cooperatives, Inc., vice-chairman of the Section, will preside at the general session Tuesday morning.

"Demonstration of Equipment for Quick, Inexpensive Method of Making Lecture Slides," by F. B. Wright, Cornell University, is listed as the program opener.

"You Can Solve the Traffic Problem" is the challenging title for a second contribution, to be made by Geo. C. Lowe, Atlantic Refining Co.

Following an intermission a panel discussion on "Training and Placing of Agricultural Engineers" will be led by O. C. French, Cornell University, as moderator, and will feature discussions by L. H. Skromme, New Holland Machine Div., Sperry Corp., B. P. Rines, University of New Hampshire, H. H. Beaty, Edison Electric Institute; and T. W. Billings, G. L. F. Farm Supplies.

Four concurrent programs on Wednesday morning are to feature more specialized subject matter interests in the Section area.

For the farm structures group J. R. Dodge, BPISAE, U.S. Department of Agriculture, will preside over a session offering papers on "Study of Wind Damage to Farm Buildings," by John E. Scofield, Cornell University, "Research in Wind-Resistant Farm Building Construction," by D. N. Doyle, Forest Products Laboratory, U.S. Department of Agriculture; "Engineered Farm Structures," by William R. Ganser, Jr., Timber Engineering Co.; and "Recent Developments in Building Research," by Wm. A. Russell, Housing and Home Finance Agency.

W. J. Ridout, Jr., Electricity-on-the-Farm Magazine, will wield the gavel bringing the rural electric group to order to hear first three viewpoints on "The Use of the Combine Milker and the Bulk Handling of Milk in the Northeast." A. C. Gustafson and George H. Hopson, DeLaval Separator Co., and A. C. Fisher, General Ice Cream Co., are the scheduled speakers. Additional individual papers on this program are "How to Compute Requirements for Standby Generation Equipment," by Ralph J. Bugbee, Central Vermont Public Service Co.; "Conveying and Distributing Chopped Hay in the Mow," by Hugh J. Hansen, Cornell University; and "Summary of Heat Pump Studies Throughout the United States," by E. R. Ambrose, American Gas and Electric Service Corp.

Power and machinery men, with S. L. Tallman, Massey-Harris Co., Ltd., presiding, will hear five presentations, as follows: "The Application and Advantages of Hay Crushers," by E. W. Hamilton, Allis-Chalmers Mfg. Co.; "Reducing Losses in the Harvesting of Forage Crop Seed," by C. G. E. Downing, Ontario Agricultural College; "Developments in the Potato Harvesting Field," by Howard D. Bartlett, Maine Experiment Station, "An Effective Method of Analyzing the Forces in a Tractor Three-Point Linkage," by L. C. Rogers, Massey-Harris Co., Ltd., and "Different Methods of Storing Grass Silage," by Angus Banting, Macdonald College, Quebec.

The Soil and Water program with Harold E. Gray, Cornell University presiding, will bring to attention "Estimation of Water Requirements of Crops from Evaporation Data," by W. H. M. Morris, Cornell University; "The Ground Water Situation in the Northeast," by R. G. Cushman, Ground Water Branch, U.S. Geological Survey; "Variations in Seasonal Requirements for the Irrigation of Truck Crops," by Byron Janes, University of Connecticut; "Water Management on the Buffalo Creek Flood Control Project," by Leon F. Silberberger, Soil Conservation Service, U.S. Department of Agriculture; and "Wells for Water Supply," by E. W. Bennison, Edw. E. Johnson, Inc.

C. G. E. Downing, Ontario Agricultural College, is to preside at the closing general session, Wednesday afternoon, featuring grain drying and forage harvesting. "Storage and Drying of Grain," by Leo E. Holman, BPISAE, U.S. Department of Agriculture, and "Drying of Ear Corn," by Geo. J. Burkhardt, University of Maryland, will picture the current status in those fields. "Comparative Efficiency of Harvesting Forage Crops" by Lowell E. Campbell, BPISAE, U.S. Department of Agriculture is the concluding item on the technical program. The business meeting of the Section will follow, after a short intermission.

ASAE Meetings Calendar

August 25-27 — NORTH ATLANTIC SECTION, University of Maine campus, Orono

September 8 and 9—ASAE PROGRAM, Centennial of Engineering Convocation, LaSalle Hotel, Chicago, Ill.

October 9 and 10 — PENNSYLVANIA SECTION, Penn Wells Hotel, Wellsboro, Pa.

October 30 - November 1 — PACIFIC NORTHWEST SECTION, Oregon State College, Corvallis

December 15-17—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

June 15 to 17 — 46TH ANNUAL MEETING, Hotel William Penn., Pittsburgh, Pa.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

SAE Tractor Meeting

THE Society of Automotive Engineers announces that its National Tractor Meeting will be held at the Hotel Schroeder, Milwaukee, Wis., September 9 to 11, inclusive. No program for the meeting has yet been announced.

(News continued on page 508)

NEWS SECTION (Continued from page 506)

Nominations for 1953 ASAE Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nomination of candidates for the 1953 awards of those two medals.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and make their nomination accordingly. The John Deere Medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to evaluation by the engineering criteria of practicality and economic advantage.

The Cyrus Hall McCormick Medal is awarded "for exceptional and meritorious engineering achievement in agriculture." Selections for the award may be in recognition of a single item of engineering achievement, but is more likely to be on the basis of the aggregate of weighted accomplishment through a continuing career.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will accept and consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

Machinery Features Hawaii Section Program

A MOTION picture featuring the various kinds and applications of the John Deere line of farm machinery opened the program of a meeting of the Hawaii Section of the American Society of Agricultural Engineers held at the University of Hawaii, Honolulu, June 18. Following the showing of the picture, A. E. Botsford, of the San Francisco office of Deere and Company, gave his impressions on types of agricultural machines in use in the Hawaiian Islands, and predicted a trend toward lighter, single-purpose machines to replace many of those now in use on the plantations which do several jobs at one time and are of a larger size. The use of smaller equipment, while involving more units, would make possible operation at higher speed. Mr. Botsford, speaking on new developments in farm machinery in general, pointed out the advantage of integral equipment, remote control of hydraulically operated implements, and use of the "live" power take-off. He also praised the standards program of ASAE for its contribution to more effective use of power units and implements of different makes.

Oklahoma Section's Spring Meeting

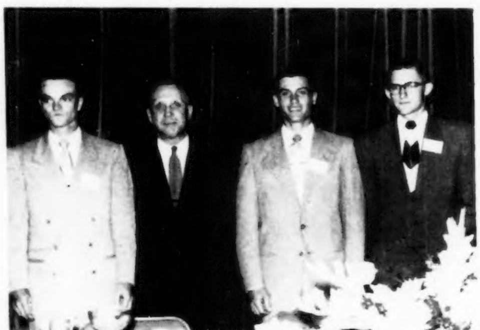
FORTY-EIGHT persons, including agricultural engineers and their wives, gathered at Stillwater on June 27, for the spring meeting of the Oklahoma Section of the American Society of Agricultural Engineers. The forenoon was given over to an informal program of fellowship, outdoor sports, and recreation at Fair Park in Stillwater. The members of the Oklahoma A & M College Agricultural Engineering Wives' Club served as hostesses for the outdoor picnic dinner served at noon. Maurice B. Cox, chairman of the Oklahoma Section, conducted a brief program of introductions and reviewed plans for activities of the Section for the ensuing year.

The afternoon program consisted of a special tour and demonstration of research and testing facilities at the USDA Soil Conservation Service Outdoor Hydraulic Laboratory at Lake Carl Blackwell. The demonstrations were carried on by W. O. Ree, in charge of the Laboratory, and Frank Crow of Oklahoma A & M College. Experimental work on flow characteristics through models of rectangular culverts equipped with weir sills as low flow measuring devices was demonstrated by Mr. Crow. Mr. Ree staged several demonstrations of flow conditions in grass-lined experimental waterways.

One of the highlights of the tour of the outdoor laboratory was the inspection of the reservoir and testing facilities for obtaining flow characteristics on a pipe outlet system typical of those used on detention reservoirs in the Washita River flood control project. These facilities have recently been completed and tested under the direction of Mr. Ree. The final event of the tour was an exhibition of flow of approximately 175 cfs through a concrete-lined chute structure equipped with a St. Anthony Falls-type stilling basin. (News continued on page 510)

(Left) These twin powerhouses – Lloyd W. Hurlbut, chairman, Meetings Committee, and Paul N. Doll, chairman, Committee on Arrangements – got the 1952 ASAE annual meeting off to a good start that carried it through to a happy ending • (Right) Henry Dreyfuss, distinguished industrial designer – and a newly elected member of ASAE – interestingly discusses the work of the "silent partner of the engineer" before a packed auditorium at the 1952 ASAE annual meeting

Leaders of the ASAE Mid-Central Section, host section to the Society at its 1952 annual meeting in Kansas City, Mo., who played important parts in connection with the meeting activities • (Left to right) John M. Furguson, junior past-secretary of the Section; Robert P. Beasley, present secretary; Chauncey W. Smith, present Section chairman; Lloyd W. Hurlbut, chairman 1951-52 (Society) meetings committee; Paul N. Doll, past-chairman of Section and chairman of arrangements committee for the Kansas City meeting; Victor Richardson, transportation chairman for the meeting, and Mack M. Jones, a past-secretary of the Section



This group includes the new officers of the National Council of ASAE Student Branches elected during the 1952 annual meeting of the Society at Kansas City, as follows: President, Morris E. Schroeder, Pennsylvania State College (second from right); vice-president, Wesley L. Harris, University of Georgia (extreme right), and secretary, John B. Nichols, University of Nebraska (extreme left). The fourth man (second from left) is the chairman of Society's Committee on Student Branches, Carlton L. Zink, product research engineer, Deere & Company

NEWS SECTION (Continued from page 508)

New Patent Applications for Cotton Ginning

THE USDA Cotton Ginning Laboratory staffs at Leland, Miss., have been conducting fundamental and applied research studies in cotton ginning processes relative to the evidently different levels of moisture content necessary in each individual stage of handling to obtain the optimum quality of fiber and the best operating efficiencies. The first studies were those that led to the development of the USDA drying process, now extensively used around the world. More recently, as a part of their program for better ginning, the engineers and technologists are working toward moisture content controls, equipments and elements that will eliminate both the former damages from wet and damp fibers as well as those that frequently have been overdried through abuse of the driers. The work has progressed to a point where it is possible to apply for a public patent by the staffs of the Ginning Laboratory, covering a triple-stage method of applying limited additional moisture to the fiber necessary for more effective operation and lessened fiber damage at three points in the ginning system, i.e., immediately following the bulk precleaning and extracting, between the feeders and the gin stands, and finally before the ginned lint enters the main lint flue leading to the condenser.

Another patent application has been made by the ginning engineers covering a special rib development and extracting device for removing cumbersome sticks from seed cotton during the extracting stages of cotton ginning. At present it is impossible to do a good job of ginning if quantities of sticks remain in the seed cotton when it reaches the feeder apron and the gin stand. This invention will be field-tested in Oklahoma after fabrication and preliminary runs at Stoneville, Miss.

Conservation Short Course

A SPECIAL short course in soil and water conservation for foreign students was held at the University of Georgia, Athens, June 16 to July 26. It was arranged and conducted cooperatively by the agricultural engineering department, University of Georgia, the food and agriculture division, Mutual Security Agency, and the Office of Foreign Agricultural Relations and the Soil Conservation Service, U.S. Department of Agriculture.

The first week was devoted to subjects on organization and procedure, including research, educational programs, and agencies.

During the second, third and fourth weeks one day was given each of a number of pertinent topics such as land use planning, surveys and land use mapping, water disposal systems, contour farming, terrace construction, farm ponds and reservoirs, supplemental irrigation, mechanized conservation farming, and watershed planning.

Trainees were assigned to conservation farm families during the fifth week for field studies.

Conservation farming equipment and field plot techniques dealt with during the sixth week were followed by a critique and summary, special conferences, and graduation exercises.

ASAE members on the short course staff included A. P. Barnett, A. Carnes, J. R. Karreker, C. W. Chapman, R. H. Driftmier, T. W. Edminster, J. W. Howell, E. A. Johnson, and W. B. Land.

Whitney L. Gironard, president, Louisiana Student Branch of ASAE, receives a check to cover expense of his attending the ASAE annual meeting at Kansas City in June, from Lewis Windham, secretary-treasurer, Louisiana Anhydrous Ammonia Dealers Association. The plan to send L. S. U. agricultural engineering student to the ASAE annual meeting is sponsored by the Louisiana Agricultural Engineers Association.

Farm Tractor Safety Film Released

"FARM Tractor Safety," a motion picture produced by the Agricultural Committee of the American Petroleum Institute with the cooperation of a number of farm-safety specialists, became available in July for free showings primarily to farm audiences. It has been announced as available from film libraries of agricultural extension departments and oil companies.

The film emphasizes safety measures which farmers can adopt and practice voluntarily as helps toward realization of their farming objectives. These include avoiding carrying extra riders, and steps to prevent tipping, hitching, and highway-travel accidents. This film was given top award for farm films by the Committee on Extension at the annual meeting of the American Society of Agricultural Engineers at Kansas City, Mo., in June.

PERSONALS OF ASAE MEMBERS

A. M. GOODMAN recently retired from a 33-year career with the agricultural engineering department at Cornell University, to take up a new assignment. He will be one of the four Cornell specialists who will engage in teaching and research work at the University of the Philippines. As extension agricultural engineer at Cornell, Mr. Goodman was widely known and highly regarded by the farmers of the state. His particular specialties have been the design, construction, maintenance and repair of farm buildings as well as their ventilation.

L. R. KOONTZ has been promoted in the Appalachian Electric Power Co., from system rural sales supervisor to system rural and residential sales supervisor. He has been with the company since 1930.

GEORGE E. WEBSTER recently completed graduate work for the Ph.D. degree at Cornell University and accepted a position as head of the agricultural engineering department at the National Agricultural College, Doylestown, Pa.

NEW BOOKS

FARM GAS ENGINES AND TRACTORS, by Fred R. Jones. (Third edition). Cloth, xii + 489 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc. (330 W. 42nd St., New York 36, N. Y., also Toronto and London). $6.00.

This brings up to date an established text originally published in 1932 and revised in 1938. A chapter on basic thermodynamics and its application to heat engine design has been added, along with new material on LP gas, hydraulic transmissions, and hydraulic controls. Both text and illustrations have been further revised to cover current equipment and practice. Chapters cover Survey of farm power, Farm power sources and adaptability, History and development of the internal-combustion engine and farm tractor, Types of farm tractors, Power and its measurement—fuel consumption — engine efficiency, Thermodynamic principles and applications—engine cycles and efficiencies, Engine construction and design, Engine cycles and principles of operation, Tractor-engine types and construction, Valves and valve operation, Fuels and combustion, Fuel-supply and carburetion systems, Air cleaners, Cooling and cooling systems, Governing and governing systems, Ignition methods —fundamentals of electric ignition, Storage cells and batteries, Magnets and magnetism—induction, Battery ignition systems, Mechanical generation of electricity—magneto ignition, Diesel-engine construction and operation, Electric generators—starters—lighting, Lubricants and lubrication systems, Tractor clutches, Tractor transmissions and accessories, Tractor chassis—traction devices—pneumatic tires—steering mechanisms, Tractor power rating—Nebraska tractor tests, Tractor hitches and field operation, Gas-engine and tractor servicing and maintenance, Economics of tractor utilization, and Materials of construction — power transmission.

SAE HANDBOOK (1952 edition). Cloth, 946 pages, 8½ x 11 inches. Illustrated and indexed. Society of Automotive Engineers (29 W. 39th St., New York 18, N. Y.).

General arrangement of contents follows that adopted for the new page size first published last year. Indicated new standards, recommended practices and reports apply to cut steel wire shot; test strip, holder, and gage for short peening; procedures for using standard shot peening test strip, classification of elastomeric compounds for automotive resilient mountings; latex foam rubber, sponge and expanded cellular rubber products; nonmetallic gaskets for general automotive and aeronautical purposes; automotive lubricating greases; fluids for hydraulic torque converters and fluid couplings; fiberboard test procedure; sleeve-type half bearings; steel tubing, single-wall construction; steel tubing, double wall construction; hydraulic flanged tube, pipe and hose connections, 4-bolt split-flange type; hydraulic hose and fittings; circuit breakers; sealed lighting unit for construction and industrial machinery;

(Continued on page 512)

NEW BOOKS

(Continued from page 510)

spot lamps; radiator filler necks; automotive brake definitions and nomenclature; definitions for braking terminology and brake operation terminology; color code for location identification of combination lining of two different materials for two-shoe brakes; sound deadeners and underbody coatings; keys for motor vehicle locks; truck ability prediction procedure; truck tractor fifth wheel heights; truck tractor minimum clearance from back face of cab to front of trailer body; scraper cutting edge; crawler tractor side-mounted booms; and hydraulic power pumps.

Revisions have been made in items on chemical compositions of SAE alloy steels; chemical compositions of SAE wrought stainless steels; general characteristics and heat treatment of steels; method of determining hardenability of steels; physical requirements for bolts, cap-screws, studs and nuts; automotive gray iron castings; automotive malleable iron castings; tool and die steels; classification of iron and steel arc welding electrodes; cast shot and grit for peening and cleaning; surface finish; wrought copper base alloys; rubber and synthetic rubber compounds for automotive and aeronautical applications; coolant system hoses; fuel and oil hoses; automotive brake hoses; windshield wiper hose; rubber cups for hydraulic activating cylinders; hydraulic brake fluid; automotive rubber mats; transmission and axle lubricant classification; screw threads; cotter pins; automotive tube fittings; hydraulic tube fittings; automotive filler and drain plugs; lubrication fittings; automotive wiring; insulated cable; storage batteries; magneto mountings; distributor mountings; headlight switching; lighting equipment for motor vehicles; license plate lamps; turn signal units; electric emergency lanterns; piston rings and grooves; piston and ring nomenclature; engine mountings; brake linings, rivets, and bolts; tractor and implement disk wheels; application of hydraulic remote control to farm tractors and trailing-type farm implements; and rear power takeoff and mounting face for industrial (track-type) tractors.

FARM MACHINE MANUALS. Separate instructor and student manuals on each of nine primary types of farm machines have recently been announced by the Agricultural Education Service, Vocational Division, U.S. Office of Education, which cooperated with representatives of industry in preparing the material. Factual information supplied by the industry was put in teaching form by A. H. Hollenberg, specialist in agricultural education (farm mechanics) and by E. J. Johnson, program planning specialist in the Office of Education. Machines covered are the baler, combined harvester-thresher, corn picker, cultivator, grain drill, manure spreader, mower, planter, and plow. The manuals are designed for training in operation, service, adjustment and care of the machines for all age farm groups, for veterans on-farm training, and for the extension workers and teachers of vocational agriculture. Prices for the manual on each machine are 25 cents for the instructor manual and 15 cents for the student manual. Orders should be sent direct to the French Bray Printing Co., Candler Bldg., Baltimore 2, Md.

AIR APPLICATOR INFORMATION SERIES. Vols. 1-6. Paper, 531 pages, 6 x 9 inches. Illustrated. Air Applicator Institute (412 Scott Bldg., Portland, Ore.) $12.50 per set.

Practical information for contract operators and others interested in dusting, spraying, seeding and fertilizing from airplanes, published in separate booklets on "Knowing Agricultural Chemicals," "Understanding Crops and Pests," "How to Spray and Dust," "Selecting Efficient Equipment," "Answers to Legal Problems," and "Directory—Where to Find It."

HANDBOOK OF ENGINEERING FUNDAMENTALS (second edition), edited by Ovid W. Eshbach. Semi-flexible, x + 1322 pages, 5½ x 8½ in. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) $10.00.

The general plan of the first edition (1936) is retained but the work has been enlarged by 240 pages, including a new section on aerodynamics and revision and rearrangement of material in other sections to bring the information up to date. Increased attention is given to engineering tables, statistics, determinants, vector analysis, the M K S unit system, properties of dry air, non-metallic materials, and engineering law. As revised the sections cover mathematical and physical tables, mathematics, physical units and standards, mechanics of rigid bodies, mechanics of deformable bodies, mechanics of compressible fluids, aerodynamics, engineering thermodynamics, electricity and magnetism, radiation, light, and acoustics, chemistry, metallic materials, non-metallic materials and engineering law.

SOILS AND SOILS FERTILITY, by Louis M. Thompson. Cloth, xi + 337 pages, 6 x 9 inches. McGraw-Hill Book Co., Inc. (330 W. 42nd St., New York 36, N. Y.) $5.00.

A new addition to the publisher's series in the agricultural sciences edited by R. A. Brink, this book is a text for a beginning one-semester course in soils for students of agriculture. Chapters cover Introduction, The physical properties of soils, Soil moisture, Biological properties of soils, Chemical composition of soils, Soil formation and classification, Clay minerals, acidity, and alkalinity, The Principles and practice of liming, Nitrogen, Phosphorus, Potassium, Fertilizers, The Utilization of farm manure, Sulfur and the minor elements, Variations in plant composition, Crop rotations and soil fertility, and Soil erosion and its control.

HYDRAULICS FOR MOBILE EQUIPMENT

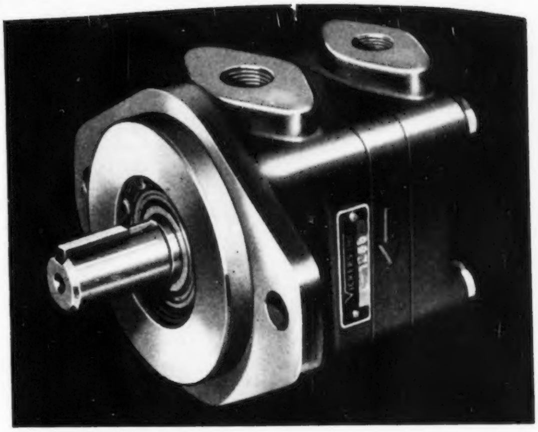
Mobile Equipment News

IMPROVES PERFORMANCE • CUTS COSTS

VOL. 1 — VICKERS INCORPORATED, DETROIT, MICHIGAN — NO. 1

NEW VICKERS SERIES V-100 PUMPS ADDED TO MOBILE EQUIPMENT LINE

Compact, efficient, rugged . . . this new and smaller addition rounds out the Vickers line of vane type pumps designed especially for mobile equipment. These pumps have established a reputation for doing a better job and lasting longer . . . at lower overall cost.



HYDRAULIC BALANCE MEANS LONGER PUMP LIFE

The two internal outlet ports are diametrically opposite each other. The same is true of the inlet ports. Thus equal and opposite thrust loads eliminate bearing loads due to pressure. Lighter bearing loads mean much longer bearing and pump life.

AUTOMATIC WEAR COMPENSATION MAINTAINS TOP PERFORMANCE THROUGHOUT PUMP LIFE

Radial compensation for wear is in the vanes. The vanes slide freely in the slots and are moved out into contact with the cam ring by centrifugal force . . . then held there by hydraulic pressure as it builds up. As normal wear occurs, the vanes just move further out in the slots to compensate. (Wear is minimized because all parts are lubricated by the oil under pressure.)

Axial compensation is by means of a pressure plate held to correct running clearance by pressure from the system. It automatically moves in to compensate as wear occurs.

Automatic compensation eliminates need for "run in" . . . efficiency is maximum the first time the pump is started. It also assures maximum delivery over a very long life, with none of the gradual falling off encountered where there is no wear compensation.

V-100 PUMPS AVAILABLE IN 3 CAPACITIES

The Series V-100 Pump is available in three capacities: 1.5, 2.5, and 3.5 gpm at 1200 RPM and 0 outlet pressure. This choice of three capacities with same exterior dimensions facilitates matching pump to the job.

Ask for Installation Drawing No. 152060.

GREATER MOUNTING ADAPTABILITY

Series V-100 Pumps are available in two mounting styles . . . flange (magneto type) and foot mounting. The pressure connection can be placed parallel, opposite to or at a right angle in either direction to the inlet by simply unbolting and rotating the pump head. Shaft drive is in either direction depending only on internal assembly.

NO-LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes expand and pumping begins.

OTHER VICKERS BALANCED VANE PUMPS FOR MOBILE EQUIPMENT

Series V-200 pump made in 4 delivery ratings—2 to 11 gpm.

Series V-300 pump made in 4 delivery ratings —12 to 24 gpm.

Series V-400 pump made in 2 delivery ratings— 28 and 36 gpm.

Series V-500 pump in 2 delivery ratings — 50 and 65 gpm.

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1516 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

4903

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

APPLICANTS FOR ASAE MEMBERSHIP

The persons listed below have applied for admission to membership or for transfer or membership grade, in the American Society of Agricultural Engineers. Members of the Society who wish to commend or object to any of these applicants, should write the Secretary of the Society at once.

BAGGETT, BENNIE D.—Agricultural engineer (SCS), USDA, Beaumont, Texas

BAKER, HARRY H.—President, A. Baker Mfg. Co., South Bend, Ind.

BRAZEE, ROSS D.—Research assistant, agr. engr. dept., Michigan State College, East Lansing, Mich.

BUTLER, JOE B.—Chairman, dept. of civil engr., Missouri School of Mines and Metallurgy, Rolla, Mo.

CAMPBELL, WILLIAM C.—Design and sales engineer, Shaw Pump and Supply, Inc., 1945 Santa Fe Ave., Los Angeles, Calif.

CHATERJI, GURU D.—Assistant foreman, agr. engr. div., Indian Agricultural Research Institute, New Delhi, India

COLLINS, DALE T.—440 W. 6th St., Junction City, Kans.

COX, RICHARD D.—Junior project engineer, Goble Disc Div., Massey-Harris Co., Fowler, Calif.

CRAFT, CHARLES E.—Explosive salesman, E. I. duPont de Nemours & Co., Wilmington, Del.

DAVIDSON, WILLIAM E.—Test engineer, General Electric Co., Erie, Pa.

FOSTER, BRUCE A.—Assistant editor, *Farm Implement News*, 608 S. Dearborn St., Chicago 5, Ill.

HARMON, JAMES P.—Sales service engineer, The Goodyear Tire & Rubber Co., 1144 E. Market St., Akron, Ohio

HEINJE, ROBERT F.—Production design engineer, John Deere Ottumwa Works, Ottumwa, Iowa

JACOBS, CLINTON O.—Instructor, agr. engr. dept., Kansas State College, Manhattan, Kans.

LINDER, PAUL—Farmer, Hartley, Iowa

MASTERS, ALLEN L.—Design engineer, J. I. Case Co., 2100 Des Moines Ave., Burlington, Iowa

NEWCOMBE, DENNIS R.—Assistant chief development engineer, Messrs. Steel Fabricators (Cardiff) Ltd., Pengam Rd., Roath, Cardiff, Wales

PANDEY, DEOTA—Assistant engineer, Central Tractor Orgn., Ministry of Agr., P.O. New Pusa, New Delhi, India

RAMSOUR, WALTER A.—U.S. Army, R.R. 3, Junction City, Kans.

SCATES, CLARENCE B.—Plant engineer, L. M. Lockhart Ranch, Hinkley, Calif.

SCHUDT, HAROLD M.—General mgr., Allis-Chalmers Mfg. Co., 2509 E. Broad St., Gadsden, Ala.

SMITH, NOEL J.—Ensign, U.S. Navy, USS Toledo, CA-133, FPO, San Francisco, Calif.

SODERHOLM, LEO H.—Assistant agricultural engineer, div. of farm elecn. (BPISAE), USDA, University of Nebraska, Lincoln, Nebr.

SULLIVAN, HERBERT D.—Layout draftsman, International Harvester Co., Old Bemestown Road, Memphis, Tenn.

VILLARS, HENRY B.—Farmer, Charles E. Borgaard Farm, Minden, Nebr.

WAYNE, FREDERICK W.—Mgr., irrigation div., Joseph G. Moore Co., Santa Maria, Calif.

WICKERT, CHARLES J.—Design draftsman, S. L. Allen & Co., 5th St. and Glenwood Ave., Philadelphia 40, Pa.

YOUNG, G. FRANK—Agricultural sales mgr., Allis-Chalmers Mfg. Co., 4646 Peachtree Blvd., Chamblee, Ga.

TRANSFER OF MEMBERSHIP GRADE

PFLUG, IRVING J.—Assistant professor, agr. engr. dept., University of Massachusetts, Amherst, Mass. (Associate Member to Member)

SCHWENDEMANN, D. E.—Assistant sales promotion mgr., Detroit Diesel Engine Div., General Motors Corp., 13400 W. Outer Drive, Detroit 28, Mich. (Associate Member to Member)

NEWS FROM ADVERTISERS

(Continued from page 448)

Two New General-Purpose Tractors

Deere and Company, Moline, Ill., recently announced the production of two new general purpose tractors, Models 50 and 60. The Model 50 is rated as a heavy-duty 2-plow size and the Model 60 a heavy-duty 3-plow size. The Model 60 is also available in a high-clearance type. Both models are available in gasoline-engine types as well as with the Deere two-cylinder all-fuel engine. Regular equipment includes 10, 11-38 and 11, 12-38 rear tires, belt pulley, conventional transmission-driven power take-off, 12-volt starter and lighting system, dry-disk clutch, adjustable rear wheel tread (50-88 in), and live, high-pressure hydraulic power.

One of the two new John Deere tractors

Optional extra features, in addition to the gasoline engine, include engine-driven live power take-off, a variety of front-end assemblies and tire equipment, and rear exhaust.

Power take-off and drawbar hitch locations conform to ASAE standards. Both models have six forward speeds and one reverse, 16-in front tires, 90-in wheelbase, 8 ft, 7½ in turning radius. The first four speeds, 1½, 2½, 3½, and 4½ miles per hour are the same for both models.

Details on which the two models differ are, for the Models 50 and 60, respectively, fifth speed, 5¾ and 6¼ mph; sixth speed, 10 and 11 mph; reverse, 2½ and 3 mph; belt pulley diameters, 9 and 12 in; belt pulley speed, 1250 and 975 rpm; belt speed, 3110 and 3270 fpm; engine speed (two-cylinder, all-fuel engine), 1250 and 975 rpm; bore, 4 11/16 and 5½ in; stroke, 5½ and 6¾ in; fuel tank, 16 and 20½ gal; water capacity, 5¾ and 8¼ gal; clutch disks, 7 and 10 in; rear axle diameter, 2⅞ and 3⅛ in; rear tires, 10 or 11-38, 4 ply and 11 or 12-38, 6 ply; front tires 5.50-16 and 6-16; over-all length, 132¾ and 139 in; over-all height, 81¼ and 84⅛ in; height to radiator cap, 59⅝ and 65 9/16 in; shipping weight, 4435 and 5300 lb.

Additional features include a quick-change wheel-tread adjustment, extra easy stearing, and integral tool carrier. A broad line of easy-on-easy-off matching operated equipment is available for use with these tractors. These models have not yet undergone the Nebraska Tractor Tests.

Two-Way Moldboard Plow

Harry Ferguson, Inc., Detroit, Mich., announces the addition of a new single-bottom, two-way moldboard plow to its farm implements. The implement permits plowing on the contour, and to turn furrows

Ferguson two-way moldboard plow

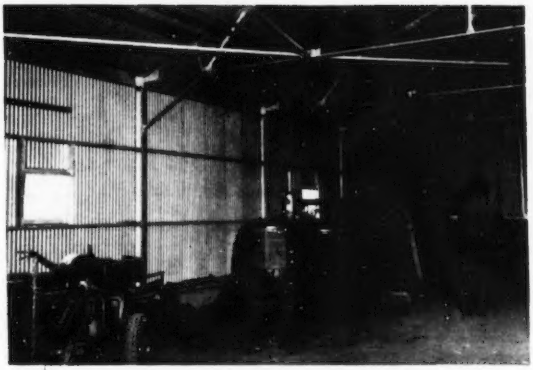
uphill without extra trips back and forth across the plowing area. In eliminating deadfurrows, the plow will operate at depths up to one foot. It is ideally adaptable for irrigated sections, because it eliminates backfurrows and deadfurrows.

From the raised position to the plowing position, each base rotates only 60 deg minimizing the shock normally found in plows rotating from 90 to 180 deg. The entire implement is raised and lowered hydraulically

(Continued on page 518)

"Steel buildings are the strongest"

says Paul Hoy Adel, Iowa



PAUL HOY wanted a building that would last a long time and give him plenty of low-cost storage area that was wind and rain-tight. After a lot of shopping around, he bought a *steel* building, measuring 36 x 60. Here's what he says about this handsome new structure.

"I think steel buildings are the strongest and most substantial buildings a farmer can construct for his farming operation. They are fireproof, rodent-proof, and stand up under all changes of weather conditions.

"When you use steel, the building can be put up so there is no post construction to fill your storage space. The U·S·S Roofing and Siding Sheets are put on with galvanized lug bolts and rubber-faced washers. This is about the strongest sheet-fastening method there is.

"Another thing I like about these steel buildings is the fact that you can put doors and windows anywhere you like, because with steel you can cut and weld together as desired."

Send the coupon and get more facts about steel buildings—if you're looking for low-cost, durable storage, well-protected from fire, lightning, rain and wind. You'll see why thousands of farmers say, "You get more for your money when you build with steel."

SEND THE COUPON FOR FURTHER INFORMATION

Agricultural Extension Bureau, United States Steel Company
Room 2804-B, 525 William Penn Place, Pittsburgh 30, Pa.

Please send me free literature about steel farm buildings. Building will be used for

Approximate size or capacity
Send information to:

Name

Address Town

County State

United States Steel Company is a steel producer, not a steel building fabricator. Your request, therefore, will be sent to building manufacturers who fabricate steel buildings for farm use.

U·S·S Galvanized Steel for Farm Buildings

You get more for your money when you build with Steel

USS

UNITED STATES STEEL COMPANY, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

2-1292

UNITED STATES STEEL

NEWS FROM ADVERTISERS

(Continued from page 516)

through finger-tip control, and the bases pivot automatically to change the direction of the furrow slice. At the end of a furrow, the finger-tip control raises the implement and automatically changes bases for the return trip. The convenient lockout lever enables the operator to raise the plow base without rotating to clear field obstructions or to cross grassed waterways.

Construction of the tubular frame assures extra strength and rigidity, and the careful distribution of weight permits less side draft and sway than in conventional implements of similar design. The high overhead steel beam insures good trash clearance and accurate alignment under all types of plowing conditions.

All parts subject to wear are specially casehardened for long life, and the individual plow bases are individually adjustable for width and vertical land suction. The rolling furrow wheel combats side draft and affords quicker penetration. Cutting width is adjustable from 18 to 16 inches with corresponding share widths available.

The implement is light enough to be stored easily by one man, and there is no danger of its tipping over when detached from the tractor.

Steel Buildings Booklet

Armco Drainage & Metal Products, Inc., Middletown, Ohio, has published a 24-page illustrated booklet on its steelox buildings (manual SX-2051). The booklet shows how two standard types — shed roof and gable roof — meet practically every need for warehouses, shops, offices and other similar structures. There are complete descriptions of how the specially designed interlocking panels are erected, with detailed drawings. Other sections deal with accessories, insulation, painting and interior finishing, and there are several pages of photographs of typical industrial and business installations. Copies may be obtained by writing the company.

A New Single-Bottom Plow

Dearborn Motors Corp., Birmingham, Mich., has announced the addition of a single-bottom, trash-covering plow to its line. A deep throat and wide throw contribute to its trash covering and soil-pulverizing ability. It is available with either a 16 or 18-in bottom with razor blade shares and replaceable shins, and designed for plowing to a depth of 10 in. The 16-in bottom with a 16-in full cut share is recommended for loose, sandy soil; a 14 or 16-in short share for stubble or stony soil; an 18-in full cut share for cutting and turning taprooted crops, and the 18 in bottom for hard-scouring muck, brush, or heavy cover. Coulter and rolling landside are fully adjustable. Many parts are interchangeable with those of the two-bottom plow.

Dearborn single-bottom plow

Iron Casting Terminology

A "Glossary of Terms for Producers and Users of Iron Castings" has recently been made available by the International Nickel Co. A 4½x7½-in booklet of 36 pages, it explains over 150 technical terms that are used in common between suppliers and users of ferrous and non-ferrous castings. It is offered to increase the mutual understanding that promotes greater accord in working out the procurement of satisfactory and improved castings. It is expected to prove useful to the designer, machinist and purchaser of castings as well as to foundry men. International Nickel Co., Dept. EZ, New York 5, N. Y.

New Roller Chain Book

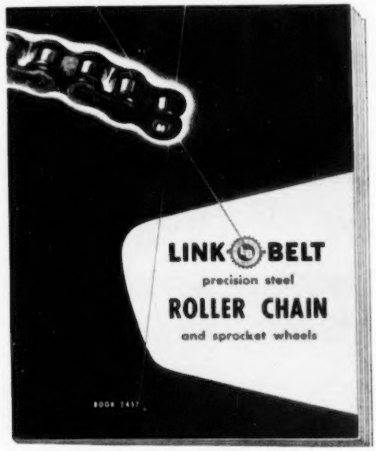
A new 148-page roller chain engineering data book No. 2457 has just been published by Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., and is now available for distribution. (Continued on page 520)

NEWS FROM ADVERTISERS

(Continuing from page 518)

It is one of the most comprehensive books ever developed on roller chain and its application. Detailed engineering information covers the selection, installation, lubrication, and maintenance of roller chain for drives and conveyors and sprocket wheels. For reference and easy identification, the book contains a large number of photographs and line drawings of the many types and sizes of chain and sprocket wheels available in the Link-Belt precision steel roller chain line. In addition, over 50 typical conveyor-chain attachments are shown.

The user, applying his information to the data in the book, can determine the proper roller chain for any application. The design notes and selection data serve as a practical textbook on the use of roller chain



Link-Belt roller chain book

for both power transmission and conveying service. Formulas, charts, diagrams and typical problems simplify selection.

To facilitate selection of drives for normal requirements, one section of 24 pages contains a comprehensive group of preselected drives which are available for delivery from stock.

Where resistance to corrosion is required, the book offers a guide to the application of stainless steel and bronze chains. Included is a table which lists the degree of resistance of these metals to 400 corrosive re-agents.

Sections on installation, maintenance and lubrication discuss such factors as shaft and sprocket-wheel alignment, chain installation and chain tension, casing assembly and methods of lubrication for varying conditions.

A copy of Book No. 2457 will be sent without charge, on request to the Company.

Peanut Digger and Windrower

Dearborn Motors Corp., Birmingham, Mich., has added to its line of farm equipment a peanut digger and windrower, designed to lift two

New Dearborn peanut digger and windrower

rows of peanuts, turn them into a single compact windrow and at the same time invert the nuts toward the sun for quick drying.

Strong construction and a minimum of moving parts are indicated features of the new digger. Two shares which dig the nuts are followed

(Continued on page 522)

NEWS FROM ADVERTISERS

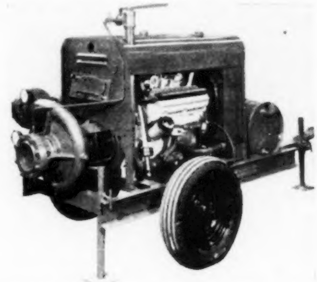
(Continued from page 520)

by two revolving conical drums, turning in the opposite direction from the tractor wheels. These drums engage the vines, carry them over the drums and lay them in a single windrow with the nuts exposed to the sun for faster drying. This action removes a considerable amount of dirt from the peanuts, leaving them ready to be gathered by a combine pickup or hand labor. Operating capacity is rated at two acres of peanuts per hour.

V8 Engine Powers Irrigation Pumps

The new Chrysler "Fire Power" V8 engine has been adapted for use on Marlow irrigation pumps. Two of the new pumps, designed expressly for sprinkler irrigation and powered by the 180-hp Chrysler industrial engine, are available. One of the new pumps, Model 6F4S, is intended for high capacity pumping at moderate pressures, while the other model, 6F1S, will develop higher pressures.

The power unit on the new pump is a heavy-duty industrial adaption of the engine now used on Chrysler automobiles. It is equipped with a much larger radiator cooling system to run at low temperatures even when operated continuously at high speeds in hot climates. A large and efficient oil bath air cleaner and Stellite valves are used to help insure dependable operation with sustained engine efficiency and minimum maintenance. Extra-long running life is obtained by designing the pumps for normal operation at 2000 rpm, though the engine



Marlow irrigation pump and Chrysler power unit on wheeled chassis

manufacturer recommends continuous speeds up to 3000 rpm. Engines are fully protected with low oil pressure and high water temperature safety controls. Water failure cutoff switches are also available. A 30-gal gas tank is safely mounted away from the engine heat. A sturdy engine housing with full instrument panel and key lock ignition are provided.

The Marlow Model 6F4S and 6F1S pumps are based on many years of experience in building and manufacturing pumps to meet irrigation requirements. Features include closed impellers, a special double-throat volute to balance radial thrust on the impeller, a newly designed bronze wearing ring to concentrate wear in a part which is easily and inexpensively replaced, and means for turning the pump volute to discharge in the most convenient direction.

Every pump is fitted with a compact and positive-acting discharge check valve. Both suction and discharge are fitted with double companion flanges to facilitate hose and pipe connections. Priming is accomplished with an engine exhaust mechanism which primes the pump at 15-ft suction lifts in less than one minute. Pumps are available as skidmounted units, or equipped with pneumatic tire chassis. Convenient tractor tongue hitches are provided for towing. Complete performance tables and detailed specifications are available from the manufacturer. (Marlow Pumps, Ridgewood, N. J.)

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to ASAE members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

TOOLS THAT HELP *YOU* PROMOTE BETTER FARMING

BROAD BASE TERRACES CAN BE QUICKLY BUILT WITH DISC AND ONE-WAY PLOWS

EVERY farmer looks at soil conservation with a practical eye. Whatever steps that are taken at his expense must be whittled to the size of his pocketbook.

That is why building broad base field terraces with the *farmer's own tools and his own labor,* has met with such wide approval. At very little cost, broad base terraces can be quickly built with disc plows, one-way plows and moldboard plows.

The plow has often been called by some a destroyer of soil fertility. But here, in building terraces, no matter what some may think of it otherwise, it is a definite rebuilder. The Massey-Harris Company, Quality Avenue, Racine, Wisconsin.

Make it a Massey-Harris

EVERY AGRICULTURAL ENGINEER HAS A STAKE IN SOIL CONSERVATION

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—FEBRUARY—O-502-557. MARCH—O-537-558, 559-561. APRIL—O-602-567, 603-568. MAY—O-619-570, 630-572. JUNE—O-657-573, 672-574. JULY—O-712-575, 622-576.

POSITIONS WANTED—MARCH—W-514-97. APRIL—W-592-109, 612-111. MAY—W-608-112, 604-113, 626-114, 629-115, 601-116. JUNE—W-633-118, 636-119, 674-120, 678-121, 661-122. JULY—W-694-123, 691-124, 682-125, 700-126, 704-127.

NEW POSITIONS OPEN

Research and design engineer to manage laboratory and aid in design and production of seat cushions, frames, and suspensions, with manufacturer of engineered transport seating. Laboratory work includes use of strain gage, stresscoat, field vibration recording equipment, vibration table, and endurance machines. Salary open. O-733-577

Instructor in agricultural engineering in a state university in the East. Duties will include teaching farm machinery, farm power and rural electrification, also extension work in farm structures or general research work, depending on tastes and abilities. Farm background essential. Salary $4000 on 12 months basis. O-736-578

NEW POSITIONS WANTED

SALES or service in farm power and machinery field with manufacturer or distributor, anywhere in western hemisphere. BS deg in agriculture, major in agricultural engineering, 1949, Ohio State University. Farm background. Part-time jobs as auto mechanic and service station manager while in school. Assistant manager of farm implement agency 18 mo. following graduation. War enlisted service in Navy as machinist mate, 13 mo. Subsequent recall to active duty for 16 mo. to end Aug. 2. Married. Age 25. No disability. Available Sept. 1. Salary open. W-692-128

DESIGN, development, or research in soil and water field with industry in South or Southeast. Willing to travel occasionally. BS deg in agricultural engineering, 1949, University of Georgia. Farm background. Part time work in college as student draftsman and blueprint machine operator. Also summer vacation experience with construction company on concrete work, block masonry, carpentry and running levels. Irrigation engineering 1½ yr following graduation, including design, sales, installation, and servicing sprinkler irrigation equipment in southern Georgia. Also demonstrated and sold tractors and tractor-operated equipment. Army enlisted service in Field Artillery since January, 1951, as research assistant on survey test work, civil-mechanical engineering. Discharge expected January 10, 1953. Married. Age 23. No disability. Available Feb. 1, 1953. Salary $3400. W-721-129

DESIGN, sales, or service in power and machinery field, or on hydraulic pumps, all types, with manufacturer or distributor in Northwest, Southwest, or Southeast. BS deg in agriculture with 12 technical electives in engineering, 1950, University of Florida. Idaho farm background. Electrician's helper, Bonneville Power Administration 2 yr, engineer's aide and electrician, Northwest Engineering and Electric Co. Currently sales engineer on machinery and mill supplies in industrial, agricultural and municipal field. War non-commissioned service 3 yr in Air Force. Married. Age 31. No disability. Available January 1. Salary open. Will consider straight commission. W-722-130

EXTENSION, sales, writing, or management in power and machinery or rural electric field in industry or federal agency, preferably in southern U.S.A. Limited travel. BS deg in agricultural engineering, 1949, Alabama Polytechnic Institute. Farm background. Part-time work at USDA Tillage Laboratory while in college. Assistant county agent assistant manager of farmer cooperative over 2 yr, including general managerial duties, sales and design of irrigation installations, sales and promotion of anhydrous ammonia, supervision of land reclamation machinery. War enlisted service nearly 3 yr. Married. Age 29. No disability. Available on 30-60 days notice. Salary open. W-693-131

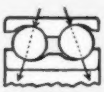
DESIGN, research or management in power and machinery field with manufacturer or consultant in Midwest or West. BS deg in agricultural engineering, 1941, University of Nebraska. MS deg in mechanical engineering, 1948, Illinois Institute of Technology. Additional graduate study at Massachusetts Institute of Technology. With major manufacturer of farm equipment 7 yr, last position, design engineer. Research professor of agricultural engineering in an eastern land grant university 4 yr. War service engineering work in industry on military projects. Married. Age 34. No disability. Available Oct. 1. Salary open. W-724-132

The bare facts about *Ball Bearings*

1 
Nothing Rolls Like a Ball. It is nature's favorite, strongest form. Having no ends, it rolls freely in any direction.

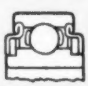
2 
Its inherent resistance to load is greatly increased by curved raceways which, under load, are partly filled by an arc of the ball. "Point contact" talk is the bunk. Actually, its contact is an ellipse, like this:

3 
This is how a ball resists thrust (axial loads) as well as radial loads—like a bicycle on a banked track.

4 
Put two rows of balls together, and you can support thrust and radial loads from any direction. They may be in one single bearing or in two separate bearings.

5 

Unlike other types of rolling elements, the ball need not be forced to travel in the proper direction. Function of separator is merely to keep balls spaced. Contact is in region of poles (point of slowest rotation—least friction.)

6 
Only ball bearings may be self-sealed with integral closures of felt and metal. In average conditions New Departures are lubricated for life. Other type bearings cannot maintain precise "inter-fitment" needed to maintain efficient self-sealing.

Rugged New Departure Ball Bearings lick friction with free-rolling, tough, forged steel balls.

They welcome today's more exacting requirements of higher speeds, heavier loads and *continued* precise positioning of moving parts.

And... most important of all, New Departure, world's largest ball bearing maker, meets your particular problems with a vast fund of experience and *original thinking.*

Cut-away view of New Departure Ball Bearing

Nothing Rolls Like a Ball...

NEW DEPARTURE

BALL BEARINGS

178

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT